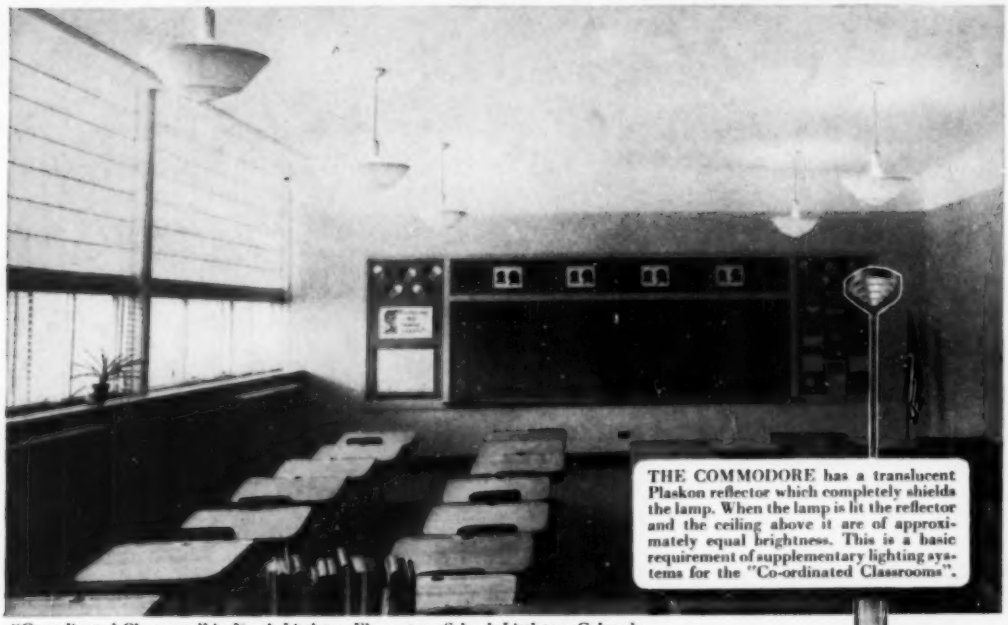
ILLUMINATING ENGINEERING

OCTOBER 1951

Calculation of Illumination from Linear Sources
Cost of Seeing a Critical Industrial Task
Threshold at Low Adaptation Levels
Maintenance of Industrial Lighting
Lighting the Cleveland Stadium
Transportation Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY



THE COMMODORE has a translucent Plaskon reflector which completely shields the lamp. When the lamp is lit the reflector and the ceiling above it are of approximately equal brightness. This is a basic requirement of supplementary lighting systems for the "Co-ordinated Classrooms".

"Co-ordinated Classroom" in North Littleton Elementary School, Littleton, Colorado

7 New Colorado Schools Have "Co-ordinated Classrooms" *lighted by Wakefield Commodores*

Architects: Atchison & Kloverstrom

THE 7 SCHOOLS:

A. H. DUNN ELEMENTARY SCHOOL
FORT COLLINS, COLORADO

HIGH SCHOOL
AURORA, COLORADO

NORTH LITTLETON ELEMENTARY SCHOOL
LITTLETON, COLORADO

2 IDENTICAL ELEMENTARY SCHOOLS
ROCKY FORD, COLORADO

ORCHARD AVENUE ELEMENTARY SCHOOL
GD. JUNCTION, COLORADO

MOFFAT COUNTY HIGH SCHOOL
CRAIG, COLORADO

Two important facts stand out here. First, when school officials and architects want to provide an ideal "total" environment for their students they turn to the "Co-ordinated Classroom". And second, when they specify lighting equipment for the "Co-ordinated Classroom" they specify a luminous indirect luminaire such as the Wakefield Commodore. There are good reasons for this:

❶ Only a luminous indirect luminaire such as the Wakefield incandescent Commodore (or the Wakefield fluorescent Star) will provide smoothly distributed, well balanced light, free from glare and sharp brightness contrasts.

❷ Only a luminous indirect fixture such as the Wakefield Commodore (or Star) will create three-dimensional seeing conditions by making the ceiling the primary light source, with the fixture itself and the side walls becoming a secondary source.

We have prepared a new 20-page booklet dealing simply but comprehensively with the subject of modern classroom lighting. For your copy of "Supplementary Lighting for the Co-ordinated Classroom", write to The F.W. Wakefield Brass Company, Vermilion, Ohio.

Wakefield **Over-ALL Lighting**

BASIC FOR CO-ORDINATED CLASSROOMS

"maintenance time cut 50%"

with Westinghouse MERCURY lighting

A typical customer's problem: "To reduce the time spent on lighting maintenance."

Westinghouse recommendation: "To install Westinghouse Mercury Lighting."

Result: "Less than half as many fixtures to maintain and fewer lamps to replace, because mercury vapor produces more light per luminaire than any other lighting system."

This is only one case out of hundreds of "time-tested" installations. All show evidence that Westinghouse Mercury Lighting is a fast growing industry favorite. Investigate the complete line: 400, 1,000 and 3,000-watt units for either low or high-bay areas . . . open or closed fixtures for clean or dirty locations . . . high or low-voltage ballasts for any distribution system. Send for B-4727, **"Westinghouse Lighting at Work" in every industrial area.** Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

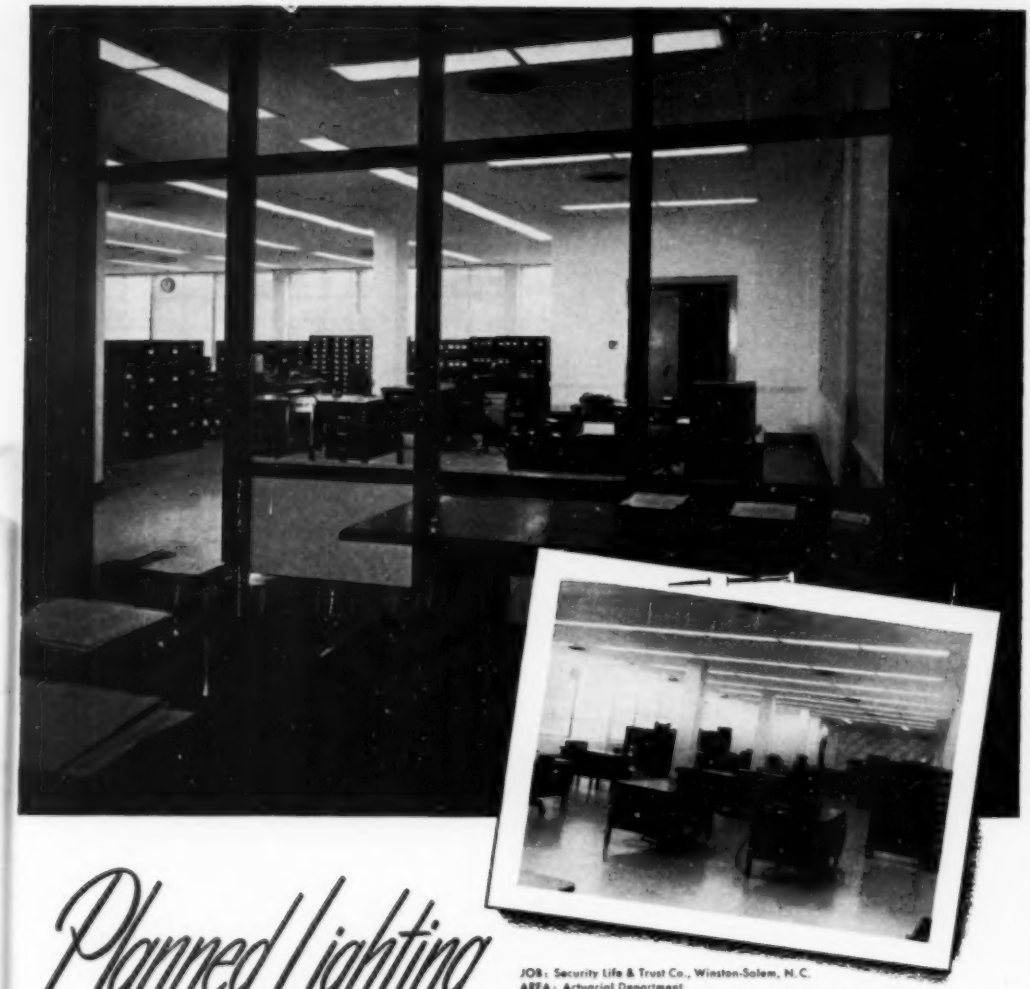
YOU CAN BE SURE.. IF IT'S

Westinghouse

LIGHTING DIVISION

Edgewater Park, Cleveland

J-04294



Planned Lighting

– BY LITECONTROL

JOB: Security Life & Trust Co., Winston-Salem, N. C.
AREA: Actuarial Department.
ARCHITECTS & ENGINEERS: Macklin & Stinson, Winston-Salem, N. C.
ELECTRICAL CONTRACTOR: Edman Electric Company, Winston-Salem, N. C.
WALL FINISH: Cream with light green wall paper.
CEILING: White.
FIXTURES: LITECONTROL No. 5828 2-lamp recessed louvered slimline fixtures.
LAMPS: T12/96 Standard Cool White.
SPACING: 8 feet on centers.
INTENSITY: Average, 57 footcandles in service.

HERE, in the actuarial department of the Security Life & Trust Company, Winston-Salem, N. C., you see visual health safeguarded by LITECONTROL Planned Lighting . . . which was used throughout the building.

In this case, the right light, in the right amount, is being shed in the right place by means of LITECONTROL No. 5828 2-lamp recessed louvered slimline fixtures. For easy servicing, louvers are hinged and may be opened from either side with spring-loaded catches.

On your next lighting problem, call in your local LITECONTROL Representative for a consultation. It will cost you nothing. Yet, this man's experience in *Planned Lighting* may mean a difference to you in terms of time, trouble and money . . . *saved.*

LITECONTROL *Fixtures*
KEEP UPKEEP DOWN

LITECONTROL CORPORATION, 36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

OCTOBER 1951

Vol. XLVI

No. 10

◆

1951-1952 Officers

S. G. Hibben — President

E. M. Strong — Vice-President

A. H. Manwaring — Vice-President

Clarence C. Keller — Gen.Sec'y

R. F. Hartenstein — Treasurer

◆

Staff

Ruby Radford
Editor

Clayton E. Ellis
Advertising Manager

◆

Publications Committee

E. C. Huerkamp, Chairman

J. M. Stedman

H. H. Magdsick

Samuel G. Hibben, President, 1951-1952 501

Experimental Check on the Accuracy of the I.E.S. Method of Measuring Horizontal Footcandles — Howard M. Sharp 502

Re-Lighting the Home of the Cleveland Indians — Merle E. Keck 503

The Threshold of Discomfort Glare at Low Adaptation Levels — Russell C. Putnam and Robert E. Faucett 505

A Method of Calculating Direct Illumination from Linear Sources — R. G. McPhail 511

Lighting Data Sheet — Series XVI
Lighting a Carpet Showroom (12-83) 521

Maintenance of Industrial Lighting — C. E. Egeler and R. F. Vanden Boom 522

Lighting Data Sheet — Series XVI
Lighting a Wall Map (10-24) 529

The Cost of Seeing a Critical Industrial Task — Willard Allphin 530

Doorways to Christmas 536

Transportation Lighting — Including Buses, Street Cars, Rapid Transit and Railway Trains 537

TELECAST — Lighting News of Current Interest 5A
Lighting Calendar, 15A; It Seems to Me, 26A; About People, 28A; Books and Pamphlets, 28A

Miscellaneous Short Items—
Luminous Ceiling Used in Hotel Restaurant, Pittsburgh, Pa., 528; Lighted Niches for Background Illumination, 535.

Officers and Council, I.E.S. 1950-1951 ..... 31A

I.E.S. Section and Chapter Chairmen for Year 1951-1952 ..... 32A

National and Local Officers 35A

I.E.S. Lighting Handbook 4A

Index to Advertisers 40A

Sustaining Members — For latest listing of Sustaining Members refer to August 1951 issue of ILLUMINATING ENGINEERING, page 14A.

◆

STATEMENTS and opinions in articles and papers in ILLUMINATING ENGINEERING are the expressions of contributors and do not necessarily represent the policies or opinions of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council of the Illuminating Engineering Society.

Founded 1906

ILLUMINATING ENGINEERING SOCIETY

A. D. Hinckley
Executive Secretary

C. L. Crouch
Technical Director

PUBLICATION office 32d Street & Elm Avenue, Baltimore, Md.

EDITORIAL and advertising offices 1860 Broadway, New York 23, N. Y.

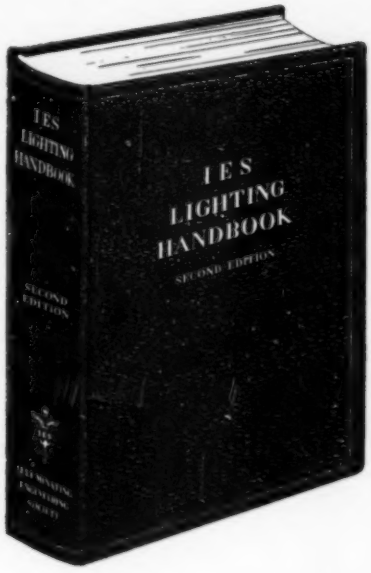
ILLUMINATING ENGINEERING: The Journal of the Illuminating Engineering Society. Copyright 1951 by the Illuminating Engineering Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. ¶ Subscription $10 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.50. ¶ Address changes must be received at I.E.S. headquarters by the first of the month to be effective with the issue of the next succeeding month.

Last Call . . . Special Price Offer

PREPUBLICATION PRICE CLOSES MIDNIGHT OCTOBER 22

Special Authorized Second Edition

IES LIGHTING HANDBOOK



Completely Revised!

17 Big Lighting Sections — Appendices — Manufacturers Data — Speed Index — 900 Pages — 655 Photos, Drawings, Lighting Tables, Charts, Graphs that make tough lighting problems easier to solve.

HERE'S HOW-TO-DO-IT HELP in tackling any kind of lighting job. Here's a one-volume book of lighting facts that gives you quick, accurate answers to all your questions. This all-new 900-page lighting Handbook, the 1951 encyclopedia of lighting, gives you step-by-step guidance through the whole vast subject of lighting, from basic theory to every-day application of good lighting to 1951 lighting problems. You get facts-you-can-use on the physics of light, vision, lighting standards, the latest trends in color lighting, light measurement, light sources, light control, coefficients of utilization tables, daylighting, exterior lighting, sports lighting, transportation, photographic, projection, reproduction lighting, miniature lamps, radiant energy. Here in one easy to use volume are all the facts you'll ever need to solve any lighting problem under the exacting limitations of materials shortages and war-time economy.

Special PRE-PUBLICATION *Offer Saves You* MONEY

To — ILLUMINATING ENGINEERING SOCIETY
1860 Broadway, New York 23, N. Y.

Please reserve for me one copy of the all-new 900-page I E S LIGHTING HANDBOOK for 1951 and send it to me immediately upon publication.

I shall examine it for ten days and if I wish to keep it shall send you the special IES member price of $4.50.* (Non-Members: $5.50.) This saves me $3.50 over the post-publication price of $8.00 or $1.00 over the special price of $5.50 for one member copy *after* publication. If for any reason I am not completely satisfied with the HANDBOOK I shall return it without obligation.

Name _____

Address _____

City _____ Zone _____ State _____

Company _____ Position _____

NOTE: If you care to send along payment with this reservation and so save the Society bookkeeping expense, your courtesy will be sincerely appreciated. Immediate refund of your money without question if you are not 100% pleased with the HANDBOOK, of course.

FREE INSPECTION COPY

We invite you to see, read, and use a copy of the Handbook *free of any charge!* Just return the enclosed FREE INSPECTION COUPON and one of the first copies to come off the press will be rushed to you. We ask you to examine it carefully, to put it to any exacting test, to satisfy yourself that it is the kind of book you need . . . or it will cost you nothing!

**The special pre-publication price to I.E.S. members is $4.50. If you returned a card stating $5.50, or sent in your check in that amount, you will be billed at the correct price or differences refunded.*

Samuel G. Hibben, President 1951-1952

Illuminating Engineering Society

TO PRESENT the career of Samuel G. Hibben, the Society's 47th President, and even a brief account of his achievements in, and services to lighting and the Society would take much more space than these short columns. His life work has been a constant search for new kinds of light and new applications of light. Many famous firsts in the field are to his credit. He helped develop the first system of transcontinental airway beacons, the first modern floodlighting installations for public monuments, and the first semi-indirect lighting for homes and offices. The relighting of Miss Liberty in New York Harbor was under his supervision.

As Director of Applied Lighting for the Westinghouse Lamp Division, Bloomfield, New Jersey, Mr. Hibben continues active, as during the past 40 years, in matters involving new illuminants, educational and lecture work, and studies of lighting applications in all fields.

Mr. Hibben's services to the lighting art coincide also with his contributions to the Illuminating Engineering Society. He joined the Society in 1910, in the same year as his graduation from Case Institute of Technology, and his entry into the then young profession of illuminating engineering, with the Macbeth-Evans Glass Company.

He has served on a great many I.E.S. committees during the years, and as a member of Council as Secretary (1922-1923) and Treasurer (1943-1944). He has been a local officer also, serving as Chairman of the New York Section (1921-1922) and is the author of numerous papers in the Society's Transactions and the trade press.

Mr. Hibben's stature in the illumination field has been recognized by the awarding of a number of honors, including his election as a Fellow of I.E.S. in 1945, the award of the Westinghouse Order of Merit, election to membership in the British I.E.S., and many invitations to lecture in several European countries as well as in the United States and Canada.

With Mr. Hibben's talent for original thinking, and taking constructive action based on sound objective appraisals, the Society may look forward to continued progress in I.E.S. affairs, and a most successful Administration.

Experimental Check on the Accuracy of the I.E.S. Method of Measuring Horizontal Footcandles

By HOWARD M. SHARP

THE I.E.S. method of measuring horizontal footcandles was adopted in 1943. Its simplicity results from weighting a few readings of footcandles taken at designated points.

The initial approach to the problem was entirely mathematical. A few check measurements were then made to assure that the accuracy was within tolerances in this type of measurement.

Experience over the years has indicated the need for a more detailed description of how to take the measurements for a wide variety of lighting layouts. In the process of this work[1] the author decided to check his own expansion of the original method and where possible, the original work.

The true average of horizontal footcandles can be found by dividing any horizontal plane into one-foot squares and averaging the footcandles measured in the center of each square. This is a very tedious job. Three rooms of different dimensions and lighting treatment were selected, all furnishings removed and one-foot square readings taken. Then the rooms were divided into squares approximately four feet each side and the readings repeated. The average illumination in all cases was found to correlate to within a fraction of one per cent.

Thereafter all measurements were made in four-foot squares. With one sixteenth the readings required the work of checking any weighted averages is relatively insignificant.

The results of the study are summarized in Table I. It is evident that any lighting system providing a high degree of diffusion such as indirect, semi-indirect, or direct-indirect can be measured to a high degree of accuracy by means of the I.E.S. method. Error in all rooms investigated is less than three per cent.

The method is therefore sound and the results well within the tolerances accepted in practice. In fact a five per cent tolerance is accepted in photometric laboratory measurements where conditions and instrumentation are under good control.

TABLE I.

Indirect Lighting	
Large room—Light ceiling, average walls	
True average	11.8 ft-c
I.E.S. method	11.5 ft-c
Per cent error	−2.5%
Small room—white ceilings and sidewalls	
True average	32.4 ft-c
I.E.S. method	32.5 ft-c
Per cent error	+.3%
Semi-Indirect Lighting	
Medium sized room—light ceiling, average walls	
Filament—enclosing glassware, enamelled bottom	
True average	18.20 ft-c
I.E.S. method	18.16 ft-c
Per cent error	−.22%
Fluorescent—URC Luminaire	
True average	29.6 ft-c
I.E.S. method	30.6 ft-c
Per cent error	+3.4%
Direct Lighting—Fluorescent Troffers—glass bottom	
Small room—2 rows continuous troffers—light ceiling, dark walls	
True average	32.2 ft-c
I.E.S. method	35.5 ft-c
Per cent error	+10%
Medium sized room—3 rows continuous troffers— light ceiling, dark walls	
True average	38 ft-c
I.E.S. method	35 ft-c
Per cent error	−8%

For direct lighting systems the error is higher, amounting to about 10 per cent. In the two rooms studied it was both a plus and minus error. Many more interiors need to be investigated in order to isolate the factors. However, until that is done the I.E.S. method of footcandle measurement can be used with confidence.

Author: Consulting Engineer, 82 Smallwood Drive, Snyder 21, N. Y.

[1]Sharp, H. M.: "An Introduction to Lighting." Prentice-Hall, New York, 1951.

1951 Proceedings Available

A limited number of copies of the Proceedings are available from I.E.S. headquarters office at a price of $2.00. The Proceedings, a paper-bound volume, contains all the published papers presented at the 1951 National Technical Conference. Address orders to Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Night game by the Cleveland Indians in the relighted Municipal Stadium. In this photograph the stands appear black as night, due to the inability of photographic film to record both the 200 ft-c level of the field and the 2 ft-c level in the stands. Since the human eye has greater latitude, the surround appears brighter when viewed from the field.

Re-Lighting the Home of the Cleveland Indians

By MERLE E. KECK

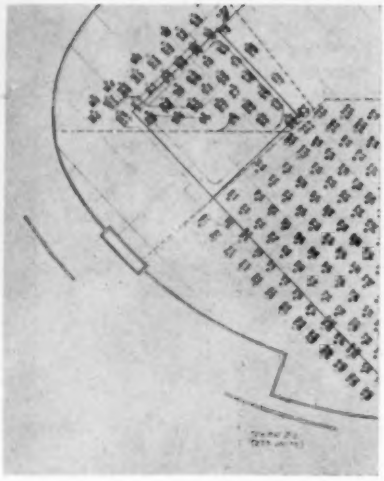
SPORTS LIGHTING is such a comparatively recent development that it is only in the past few years that the original lighting systems are becoming "worn out" and a new study of the lighting becomes necessary.

The Municipal Stadium, home of the Cleveland Indians, was first lighted for night baseball in 1939. It was well lighted then, but eleven years has seen a general rise in the level of illumination at the major baseball parks, and an ever-growing night-game schedule has caused considerable deterioration of the equipment. The lighting levels of the installation declined, during its life, from 141 footcandles initially on the infield, to 80 footcandles. This compared rather unfavorably with the 200-footcandle level in some of the other major league ball parks, and the fans, players, sports writers and owners of the Cleveland Indians yearned for much more light. Probably as a result of all this, when it was necessary to negotiate a new lease between the City of Cleveland and the baseball club, it was agreed as part of the terms, that the Stadium would be relighted.

The original six towers were modified by the addition of steel extensions in a horizontal direction so that their capacity has been roughly doubled. Originally 712 floodlights were used to light the Stadium. All of these original units were

The largest bank of floodlights ever assembled are those on the first and third base towers of Cleveland Stadium. These 273 units, each luminaire using 1740 watts of electrical energy, total 475,000 watts for this one tower alone.

Author: Westinghouse Electric Corp., Cleveland, Ohio.



Accurate daytime aiming (above) is assured by using the rifle type sights built into the floodlight and numbered targets carefully located on the field.

A portion of the aiming diagram (right) which shows where to locate the aiming targets and which floodlight is to be directed to that target.

replaced with new I.E.S. Type III floodlights and additional units added. There are now a total of 1318 floodlights, each equipped with a 1500-watt general service lamp operated at 10 per cent over rated voltage.

An aiming diagram showing the exact location where the center of each floodlight beam was to be aimed was prepared by the author for this installation. With the present cost of labor, and relatively short length of time available in the Spring for carrying out the project, it was desirable to avoid readjustment of the floodlights if possible. The aiming diagram was carefully worked out and the floodlights aimed individually in the daytime, by means of a rifle type sight built into the unit, at numbered targets carefully located on the playing field.

The complete relighting project was started late in February 1950 and completed a short week before the first night game on May 12th. The completed installation was turned on a few days before the first night game and was found to be entirely satisfactory, with an initial level of 229 footcandles on the infield and 198 footcandles in the outfield, exceeding the contract requirements. The uniformity of illumination is excellent, less than $1\frac{1}{2}$ to 1, and it was not necessary to reaim a single luminaire.

The suitability of a sports lighting installation can only be judged by its acceptance from players and fans and by the performance of the players under it. Comments from everyone concerned were favorable, with enthusiastic comments from many. Performance was equally good, and from every aspect this high footcandle level, uniformly lighted field is definitely "Major League."

For Discussors of I.E.S. Conference Papers

Are you planning discussion on any of the "Conference Papers" for publication with the paper in ILLUMINATING ENGINEERING? If so, be sure to submit it early to ensure its making the deadline, and while the Conference is still fresh in your mind. Copies of discussion should be distributed in this manner.

One copy (original) to Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

One copy to author for his rebuttal.

One copy to Hoyt P. Steele, Benjamin Electric Mfg. Co., Des Plaines, Illinois.

Three copies to discussion organizer for the session.

The Threshold of Discomfort Glare At Low Adaptation Levels

By RUSSELL C. PUTNAM
ROBERT E. FAUCETT

This paper presents a fundamental study of the borderline between visual comfort and discomfort at low adaptation levels and small glare sources. It takes into consideration the adaptation of the eye and the apparent source size as well as the brightness of the source. Fifteen observers were used in the investigation. Relationships are obtained for the borderline between comfort and discomfort in terms of adaptation level and source size. The adaptation levels range from 10 to 0.001 footlamberts and the source size from 0.0011 to 0.000001 steradian which approximate the conditions found in street lighting.

DISCOMFORT GLARE is, in essence, uncomfortable brightness relationships between the central and surrounding fields of vision which are directly responsible for the comfort of the visual conditions but show only an indirect effect upon visibility. Disability glare is, on the other hand, brightness relationships within the central zone of vision which are directly responsible for decreasing visibility of a certain task. This paper is concerned with discomfort glare.

Different degrees of comfort are physical and/or psychological sensations and therefore appraisals can only be made by persons experiencing such sensations. Individual appraisals vary between extremely wide limits but averages of such appraisals follow smooth curves closely to give definite trends.

A review of published articles on discomfort glare indicates that the factors which govern the limiting conditions of discomfort glare are: (1) the brightness of the source, (2) the visual size of the source, (3) the brightness to which the eyes are adapted (adaptation brightness), (4) the relative position of the source to the line of sight, and (5) time of exposure. The brightness ratio of the source to its background is not necessarily a factor in determining discomfort glare as the immediate surround of a light source may not be representative of the field to which the eye is adapted. Such is the case in street lighting where the background of the luminaire might well be a black sky and where the eye, being directed slightly below the horizontal, is adapted to approximately the brightness of the roadway. The brightness ratio of source to background gains importance as the adaptation brightness and the brightness of the immediate surround become more nearly the same, as in interior lighting.

It is interesting to compare the researches of Nutting,[1,2,3,4] Luckiesh and Holladay,[5] Holladay,[6] Hopkinson,[7] Petherbridge and Hopkinson,[8] and Luckiesh and Guth[9, 11] and Guth [14] with the results of this investigation. Nutting was seeking to determine the limiting condition for automobile headlight glare and from the nature of this problem and study of his method it has been concluded[10,15] that he was actually determining the borderline between tolerance and intolerance (BTI) rather than the borderline between comfort and discomfort (BCD). Luckiesh and Holladay used a method rather similar to Nutting's in which there was an element of time which allowed the adaptation of the fovea to change toward that of the brightness of the glare source. Both researches involved steady fixation of the glare source which tended to raise the adaptation level during the time of appraisal.

Actually, steady fixation of a light source seldom occurs in lighting practice. It would seem therefore to be more in order to study discomfort glare with a momentary exposure rather than a prolonged one. Holladay[6] conducted such experiments dealing with momentary fixation and found the limit of tolerable brightness to be much less than that found by Nutting. By eliminating the foveal adaptation change involved in a steady fixation of the light source, Holladay also found that size was indeed a factor in determining discomfort. He stated that when the adapting field (F) is held constant, the limiting brightness varied inversely as the 0.25 power of the solid angle subtended by the glare source (Q).

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Russell C. Putnam, Professor of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio; Robert E. Faucett, Graduate Student (presently employed by the Civil Aeronautics Administration, Technical Development and Evaluation Center, Indianapolis, Indiana.

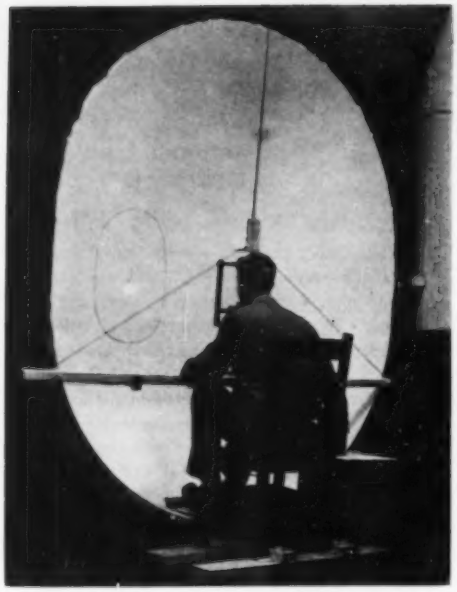


Figure 1. Front view of hemisphere with observer in test position.

Figure 2. Side view of hemisphere showing some of the auxiliary equipment.

Hopkinson[7] derived some empirical equations similar in general form to those developed in this investigation. The equations of the two investigations are not directly comparable as Hopkinson's work determined the BCD in terms of intensity (I) rather than of brightness (B).

Later work by Peterbridge and Hopkinson[8] produced a formula of the Holladay "multiple criteria" type which was derived for interior lighting applications which covered a range of brightness and source size outside the scope of the present study. It is not possible, therefore, to make a direct comparison between the two sets of experimental findings.

The recent work on discomfort glare by Luckiesh and Guth[9] and Guth[14] is pertinent to this study. Their work dealt with adaptation brightnesses from 1.0 to 100 footlamberts and glare source sizes from 0.0001 to .13 steradian. The present investigation follows their laboratory technique very closely but deals with adaptation brightnesses of 10 to 0.001 footlamberts and glare source sizes from 0.0011 to 0.000001 steradian. There is thus an overlapping range in the two investigations that can be used for comparison.

Equipment Used

The adaptation brightness was obtained by means of a two-meter hemisphere which was illuminated by a centrally located source (Figs. 1 and 2). This light was shielded from the observer as he sat with his eye at the center of the hemisphere so that an evenly controlled brightness covered his entire field of view. Measurements at various points over the inside surface of the hemisphere showed the brightness to be uniform within the accuracy of the brightness measurements ($\pm 5\%$). A wide range of calibrated lamps and filters made possible a range of adaptation brightness from 10 to 0.001 footlamberts.

This hemisphere was separated at the equator by an extra piece of sheet steel so that holes could be punched as may be needed in future extensions of this work without permanent damage to the sphere. In order to facilitate the investigation of source size, a set of templates was designed to provide visual solid angles of 0.0011, 0.0001, 0.00001, and 0.000001 steradian at the viewing distance of 1 meter (circular holes of 0.748, 0.2255, 0.0713, and 0.02255 inches in radius respectively).

The glare source brightness was obtained by mounting a lamp and a color correcting filter inside a ventilated housing and then placing the unit behind the hole in the template. The filter was made of two pieces of glass; an opal diffusing glass to improve the uniformity of the source

brightness and a blue glass to more nearly maintain a good color match between the adaptation brightness and the source. Lamp and filter combinations were devised to give excellent color matches between glare source and surround for the entire brightness range up to 60,000 footlamberts.

The flashing cycle of the glare source was controlled by a specially designed circuit which gave three one-second "on" periods separated by one-second "off" periods and followed by a five-second "off" period, similar to the Luckiesh-Guth technique. During the "off" period the glare source was not entirely extinguished but was held at a carefully controlled "stand-by" brightness which was approximately the same as that of the surround. This served two purposes. It prevented a black area from being in the field of view when the source goes "off" and it kept the filament hot during the "off" period thereby reducing thermal lag on the next pulse of current. The brightness of the glare source during the "on" period was controlled by the observer by means of a variac.

Experimental Procedure

Fifteen observers were used for most of the tests. They ranged in age from 22 to 64, with an average of 33 years. Observers came once a week on scheduled appointment. A total of 3139 BCD appraisals were recorded.

The eye position of the observer was fixed in relation to the glare source by an adjustable head rest, thereby fixing the visual angle of the glare source. The variac controlling the brightness was within easy reach (Figs. 1 and 2).

The brightness of the adaptation field was adjusted to the desired value and kept constant by the experimenter who was in charge of the work. The experimenter was in an adjoining room with the various controls and timing equipment so that the observer would not be disturbed (psychologically or otherwise) either by the experimenter or by any sound from the control relays. The observer was then asked to adjust the variac until in his judgement the borderline between comfort and discomfort (BCD) was reached.

The source was momentarily exposed to view in the ten second cycle previously described. This method was employed since this aids the observer in maintaining the adaptation for the specific field brightness under test and also since it has been found that it is easier for an observer to evaluate a sensation of brightness from a short exposure than it is to judge the same sensation when it is prolonged.[5, 6, 9, 11]

The criterion of BCD was left up to the judgment of each observer. Under each condition of adaptation brightness (F) the observer was asked to give three settings of brightness of the glare source which he considered to be the value of BCD. The first determination was a bracketed brightness where the brightness of the glare source was varied, first on the comfortable and then on the uncomfortable side, until the observer finally narrowed the setting down to the brightness which he believed to be the borderline between comfort and discomfort. After this first setting was obtained the observer was asked to start at a value that was too high for comfort and then slowly decrease the glare brightness until the BCD value was reached, trying not to overshoot. The third evaluation was made in the same manner as the second except that the observer was asked to start at a value of brightness considerably below BCD and increase until the BCD value was reached.

As each setting was made the observer notified the experimenter who recorded the voltage applied to the glare source. Calibration curves of glare source brightness in terms of applied voltage had been made for each source so that the various brightnesses could be recorded without disturbing the observer.

The adaptation brightness lamp was then changed to the one necessary to produce an adaptation brightness one logarithmic step lower (1/10 of the previous brightness) and then the above procedure was repeated. Similar determinations were made for the five adaptation brightnesses studied (10.0, 1.0, 0.1, 0.01, and 0.001 footlamberts).

The second phase of the investigation was conducted in the same manner, the difference being that the solid angle (Q) subtended by the source was varied in logarithmic steps while the adaptation brightness (F) was held constant. This was done for $Q = 0.0011$, 0.0001, 0.00001, and 0.000001 steradian for three different adaptation brightnesses ($F = 1.0$, 0.1, and 0.01 footlamberts).

Results of the Investigation

Since the experimental technique used in this investigation was essentially the same as that used by Luckiesh and Guth[9] and similar to the earlier researches of Luckiesh and Holladay[5] the results should be comparable. The first part of this study used the same size glare source (0.0011 steradian) located on the line of vision as did the previous researches and determinations were made at adaptation brightnesses of 10.0 and 1.0 footlamberts in order to check the earlier work. Fig. 3 shows this comparison, the results of this investigation being plotted for all five adaptation brightnesses while

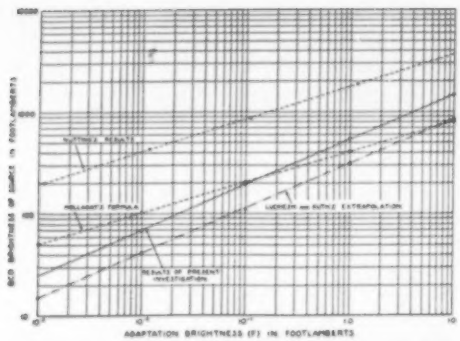


Figure 3. Comparison of the results of various researches for a source size (Q) of 0.0011 steradian.

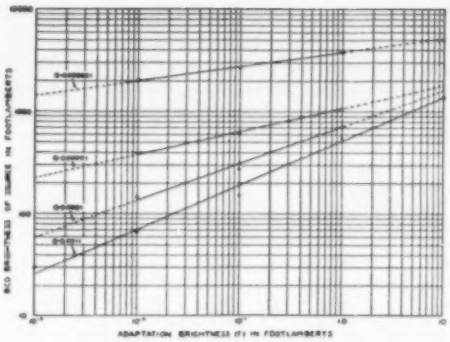


Figure 4. The relationship between BCD brightness of a source and adaptation brightness (F). The source is on the line of sight and subtends a solid angle of Q steradians.

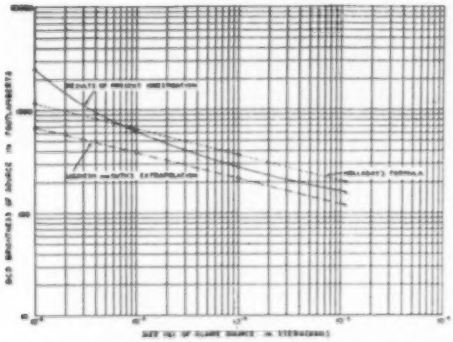


Figure 5. Comparison of the results of various researches for an adaptation brightness of 0.10 footlambert.

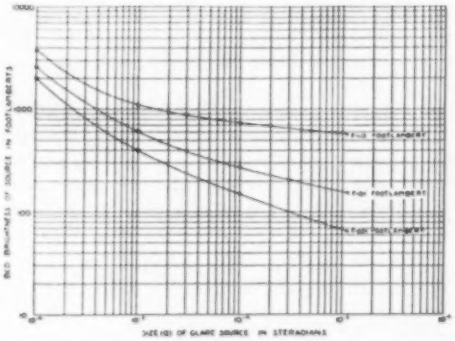


Figure 6. The relationship between BCD brightness and size of source for three different adaptation brightnesses. The sources are located on the line of sight.

Luckiesh and Guth's work is plotted for 10 and 1 footlamberts and extrapolated for the lower values.

The two curves are seen to be in close agreement. They are parallel and can be expressed by the same empirical equation (log B = 0.44 log F + a constant). Expressed in another form the equations are:

(1) $B = 302F^{0.44}$ (Luckiesh and Guth)
(2) $B = 529F^{0.44}$ (Putnam and Faucett)

The fact that different groups of observers were used in obtaining data in the two investigations accounts for the difference in magnitude shown both in the equations and the curves. This difference indicates that the average observer in the present investigation could withstand a higher brightness before discomfort was experienced than the average observer in Luckiesh and Guth's work. Luckiesh and Guth selected their ten observers to be representative of a group of fifty observers which had given an approximately normal distribution in previous BCD measurements. In the present investigation no such selection was made, the observers being used because of their availability and willingness. Three had come recently from parts of the world where high daylight brightness is common (Texas, Hawaii, Turkey) and eight of the fifteen observers had no previous photometric experience.

The important and highly significant aspect of the comparison of the results of these two investigations is that the experimental curves are parallel and the exponent of F is the same in equations (1) and (2). This shows that the two independent groups of observers, differing so much in background and experience, appraised the change in

BCD with change of adaptation brightness at exactly the same rate.

The comparison with Holladay's formula shows approximately the same magnitude and somewhat the same slope (Fig. 3). For an adaptation brightness (F) of approximately 0.15 footlambert the results of the present study agree with the calculation from Holladay's formula.

The values based on Nutting's results are considerably above those given by Holladay's formula, Luckiesh and Guth's extrapolation and the results of this investigation. As discussed earlier it has been concluded that Nutting probably was finding the threshold of intolerance (BTI) rather than the threshold of comfort-discomfort (BCD).

While the present findings agree favorably with the extrapolation of Luckiesh and Guth's equation when using the standard size source ($Q = 0.0011$ steradian) the slopes become different when smaller sources are considered (Fig. 4). As the glare source becomes very small the slope becomes less. This indicates that Luckiesh and Guth's equation cannot be extrapolated with validity to low adaptation brightnesses for sources which subtend a solid visual angle of substantially less than 0.0011 steradian. The equations for the four curves are:

(2) $B = 529F^{0.44}$ $(Q = 0.0011)$, see Fig. 4
(3) $B = 734F^{0.36}$ $(Q = 0.0001)$
(4) $B = 1115F^{0.22}$ $(Q = 0.00001)$
(5) $B = 3759F^{0.14}$ $(Q = 0.000001)$

where B = BCD in footlamberts
F = adaptation brightness in footlamberts
Q = source size in steradians.

When these data are plotted for a constant adaptation brightness (F) the curves in Figs. 5 and 6 result. These curves can be represented by the following equations:

(6) $B = 0.68Q^{-0.60} + 531$ $(F = 1.0)$
(7) $B = 0.43Q^{-0.62} + 124$ $(F = 0.1)$
(8) $B = 0.16Q^{-0.68} + 53$ $(F = 0.01)$

These equations are all in the general form

$$B = aQ^{-b} + c$$

The brightness (B) at the borderline between comfort and discomfort is a complex function of the adaptation brightness (F) and the size (Q) of a source when F varies from 1.0 to 0.01 footlamberts and Q from 0.0011 to 0.000001 steradian. These experimental results show that the BCD brightness in these ranges of adaptation brightness and source size does not vary linearly as would be indicated by extrapolations of previous investigations (Fig. 5). As the glare source becomes smaller than 10^{-5} steradian, the BCD brightness of the glare source becomes greater at an increasing rate, indicating that very high brightnesses may not be uncomfortable if the source is extremely small (Figs. 5 and 6).

Conclusions

This paper presents the results of an investigation of several of the factors involved in seeing on the highway at night, such as small source size and low adaptation brightness. In order to be able to apply these data completely and practically to the usual street lighting installation many other factors, such as the number of sources, the position of the sources in the visual field, non-uniform adaptation brightnesses, etc., must be investigated and integrated with these results.

It is significant that in the region where Luckiesh and Guth's data overlaps with this investigation the results are straight lines and are practically parallel. Also it is important to note that the curvature of BCD brightness of source curves upwards at low values of Q in this investigation and downward at high values of Q as reported by Luckiesh and Guth.[9] This is in agreement with practical experience that considerable brightness can be tolerated without discomfort if the sources are small whereas the brightness must be kept relatively low for large light sources if comfort is to be maintained, assuming other factors are unchanged.

The authors believe that this work, which is an extension of the Luckiesh-Guth technique into the field of very small glare sources and low adaptation levels, gives good agreement with previous researches where comparison can be made and is consistent with common sense in the regions where there have been no previous investigations.

Acknowledgments

The authors wish to acknowledge the helpful suggestions of Mr. S. K. Guth in respect to the original planning of the laboratory technique and the assistance of Mr. Edward Hessman with the original photographic work. They are especially indebted to

Mr. Rafael N. Benaroya
Mr. Robert C. Burgener
Mr. Russell D. Churchill
Mr. Raymond A. Elliott
Mrs. Patricia L. Faucett
Mr. James R. Guy
Mr. Nathan Hals
Mr. George W. Izant
Mr. G. W. Sanford
Mr. Ralph T. Segawa
Mr. Robert F. Wagner
Mr. Rollin W. Waite
Mr. Omer D. Whitwell

who as observers donated their time freely and willingly and thus made the investigation possible.

Bibliography

1. Nutting, P. G.: "Effects of Brightness and Contrast in Vision," *Transactions of the Illuminating Engineering Society*, Vol. 11, pp. 939-946 (December 1916).

2. Nutting, P. G.: "Optical Principles of Illuminating Engineering," *Transactions of the Illuminating Engineering Society*, Vol. 15, pp. 529-538 (November 1920).

3. Nutting, P. G.: "The Fundamental Principles of Good Lighting," *Journal of the Franklin Institute*, Vol. 183, pp. 287-302 (March 1917).

4. Nutting, P. G.: "1919 Report of Standards Committee on Visual Sensitometry," *Journal of the Optical Society of America*, Vol. 4, p. 68 (1920).

5. Luckiesh, M. and Holladay, L. L.: "Glare and Visibility," *Transactions of the Illuminating Engineering Society*, Vol. 20, pp. 221-252 (March 1925).

6. Holladay, L. L.: "The Fundamentals of Glare and Visibility," *Journal of the Optical Society of America*, Vol. 12, p. 271 (April 1926).

7. Hopkinson, R. G.: "Discomfort Glare in Lighted Streets," *Transactions of the Illuminating Engineering Society* (London), Vol. 5, pp. 1-24 (1940).

8. Petherbridge, P. and Hopkinson, R. G.: "Discomfort Glare and the Lighting of Buildings," *Transactions of the Illuminating Engineering Society* (London), Vol. 15 (1950).

9. Luckiesh, M. and Guth, S. K.: "Brightness in the Visual Field at Borderline Between Comfort and Discomfort (BCD)," ILLUMINATING ENGINEERING, Vol. 44, pp. 650-670 (November 1949).

10. Report No. 1 by the Committee on Standards of Quality and Quantity for Interior Illumination: "Brightness and Brightness Ratios," ILLUMINATING ENGINEERING, Vol. 39, pp. 713-730 (December 1944).

11. Luckiesh, M. and Guth, S. K.: "Discomfort Glare and Angular Distance of Glare Sources," ILLUMINATING ENGINEERING, Vol. 41, p. 485 (June 1946).

12. Crouch, C. L.: "Brightness Limitations for Luminaires, ILLUMINATING ENGINEERING," Vol. 40, p. 427 (July 1945).

13. Crouch, C. L.: "The Relation Between Illumination and Vision," ILLUMINATING ENGINEERING, Vol. 40, p. 747 (November 1945).

14. Guth, S. K.: "Comfortable Brightness Relationships for Critical and Casual Seeing," ILLUMINATING ENGINEERING, Vol. XLVI, pp. 65-75 (February 1951).

15. Fowler, E. W. and Crouch, C. L.: "Glare and Lighting Design," ILLUMINATING ENGINEERING, Vol. XXXVI, pp. 897-916 (November 1941).

DISCUSSION

SYLVESTER K. GUTH*: There has been much speculation regarding the relative effects upon visual comfort of the size and brightness of sources when the eyes are adapted to lower and higher brightnesses than are usually encountered in interior lighting practice. The authors are to be complimented for providing us with this extension of comfort-discomfort data into the region of low adaptation brightnesses. It is hoped that their results eventually will be supplemented by data for sources located off the line of vision and for multiple sources. When information is available for all of these conditions it should be possible to develop lighting design data which will take into consideration both discomfort and disability aspects of glare.

If this paper does nothing else, it should emphasize the hazards involved in extrapolating empirical relationships beyond the range of the experimental conditions. For example, these new data indicate that for a very small size of source (10^{-4} steradian) and an adaptation brightness of 0.1 footlambert, the BCD brightness is about 2500 footlamberts. An adjusted extrapolation (correcting for differences among the observers) of the Luckiesh-Guth data indicates a BCD brightness of about 850 footlamberts. Such a difference is important to lighting practice because the lower value may impose severe and unnecessary restrictions upon the designers of lighting equipments.

A comparison of the Putnam-Faucett BCD curves with those obtained by Luckiesh and Guth indicates the difficulty of obtaining a single simple empirical equation for a wide range of environmental conditions. Such response curves are inherently complex functions of the various factors that are involved. Fortunately, the application of such relationships usually needs to be made only for restricted ranges of conditions. Thus, it is possible to use the Putnam-Faucett data for appraising seeing conditions at night.

RUSSELL C. PUTNAM*: The authors are grateful to Mr. Guth for emphasizing some of the important aspects of the paper. The suggestions for further investigations as proposed in the paper and by Mr. Guth should be carried out as the integrated data would give valuable information to the designer of equipment for use in conditions involving low adaptation levels, particularly in the aviation, automotive and street lighting fields.

*General Electric Co., Nela Park, Cleveland, Ohio.

*Author.

Have You a Collector's Item?

Do you have any unneeded copies of the November 1940 issue (Vol. XXXV, No. 9) of ILLUMINATING ENGINEERING stored on the shelf? If so, the I.E.S. headquarters Technical Department will gladly pay postage for mailing them in to headquarters office. That issue is in particular demand and the few copies available are becoming much the worse for wear after many borrowings. Any quantity from one to fifty will be welcomed. Address: Technical Department, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

A Method of Calculating Direct Illumination from Linear Sources

By R. G. McPHAIL

A simplified method of point by point calculation of illumination from linear sources is explained. It is based on two precalculated functions derived from the candlepower distribution of the luminaire to be used. Intended primarily for figuring direct illumination from long fluorescent sources, it can also be used for rows of incandescent sources. In addition, these precalculated functions can be used to find the quantity of light falling on a strip from either a point source or an extended linear source.

EVER SINCE the advent of fluorescent lamps, the calculation of direct illumination from a long linear source has presented a problem. Some divide the source into sections and calculate the light from each section as though it were a point source. This method is accurate enough if suitable photometric data are available and if the strip is divided into small enough sections, but it is tedious because of the large number of calculations required. It would seem that there should be some method of finding the illumination from the whole strip by means of one or two simple calculations.

Several such methods have been devised, perhaps the first by Joseph C. Pole, published in 1911 in *Transactions of the Illuminating Engineering Society*.[1] Professor Higbie published a method based on graphs in ILLUMINATING ENGINEERING in 1941.[2] Professor Moon described a vector method in his textbook.[3] Other special methods for the solution of this problem have been published and nearly all textbooks give a formula for its solution. The trouble with these methods is that they involve difficult calculations and that they are limited in application because nearly all of them are based on the assumption of perfect diffusion lengthwise of the light strip. In the case of modern fluorescent fixtures with lengthwise brightness control such assumption is not very close to the truth.

Description of Proposed Method

The proposed method of calculation seeks to eliminate these difficulties; first by precalculating that part of the illumination equation which depends on the candlepower distribution of the fixture and second by basing this calculation not on a mathematical prototype, but on the measured candlepower distribution of the fixture. Thus the problem is split into two parts; first how to find the precalculated function and second how to use this function for calculating illumination on points in various locations.

Actually two precalculated functions are required; one for calculations on planes parallel to the light source, the other for planes perpendicular to the light source. They are co-functions in the same sense as the cosine is the co-function of the sine. The first has been called "*Los*" because it is generally given in terms of "*L* over *S*" (the length of the source divided by the distance to the point), the other, "*Sol.*"

Before going into the method of calculating *los* and *sol* and their mathematical derivation, however, assume that curves of these functions are available and consider how they are used for point by point calculation.

How to Use This Method

Fig. 1 shows points in various locations in reference to a linear source and on planes tilted in various directions. Chart 1 shows a family of curves giving values of *los* and *sol* for a commercial fluorescent fixture. By selecting the proper formula from Fig. 1 and using the values of *los* and *sol* given in Chart 1, any problem of point by point calculation of illumination from this linear source may be solved. Of course, in some cases it may be desirable to turn the formulae around or modify them to take care of special cases, but this can easily be done.

The meaning of the letters used in these formulae are, in general, self-evident from the drawings, but to prevent any possible confusion they are defined as follows:

E = illumination in footcandles.

I = candlepower per foot perpendicular to the light strip. It is the candlepower read from the transverse distribution curve of the unit

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Author: Holophane Co., Newark, Ohio.

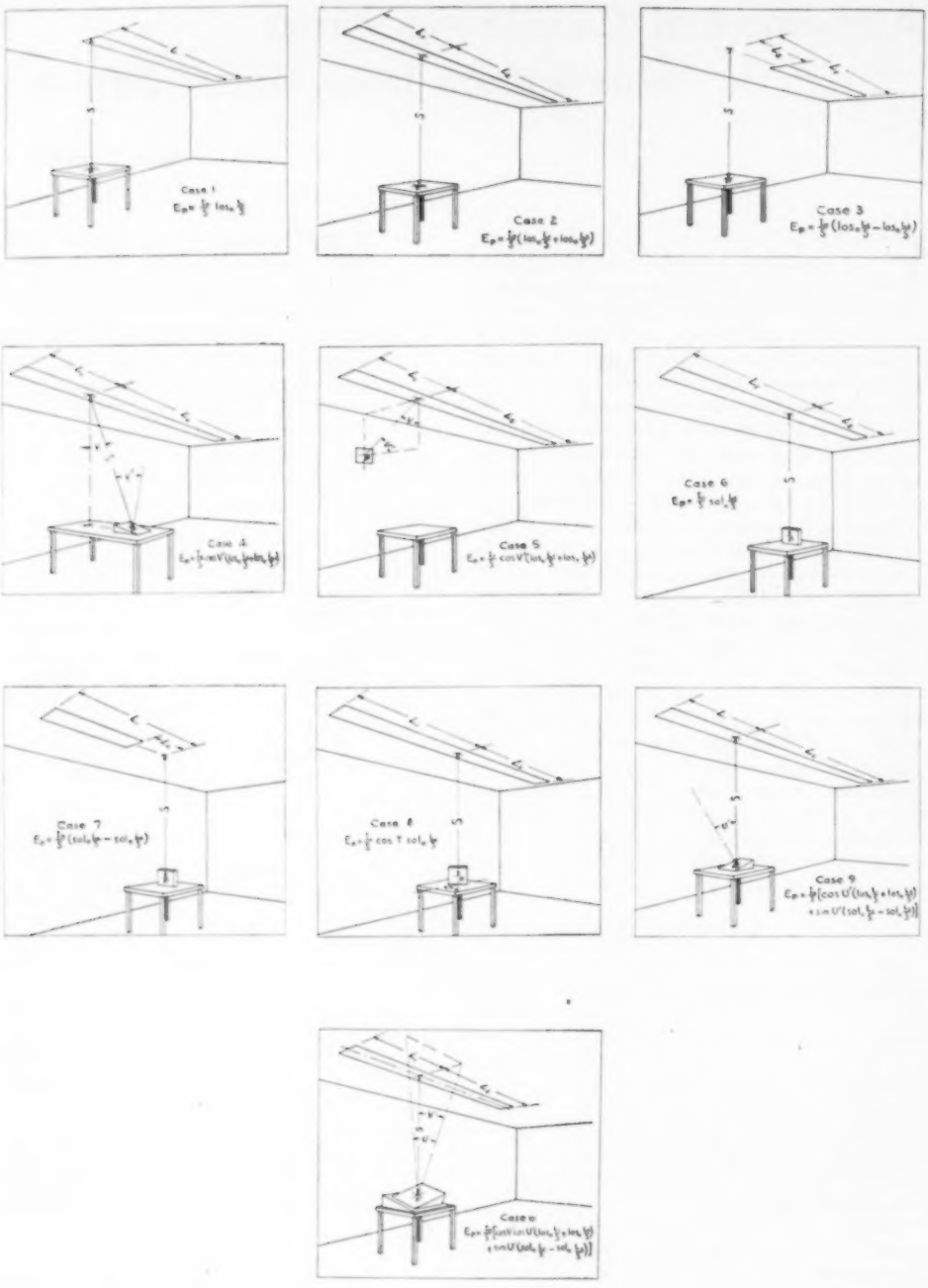


Figure 1. Formulae for calculating illumination from a linear source on points in various locations.

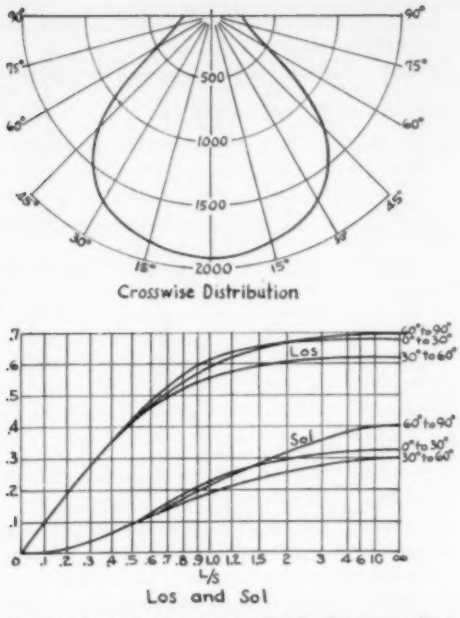


Chart 1. ***Los, Sol*** **and crosswise distribution curves for a 4-lamp, 4-ft commercial fluorescent luminaire with prismatic brightness control both crosswise and lengthwise.**

divided by the length of the unit. I_o = candlepower per foot at nadir. I_v = candlepower per foot at angle V from nadir.

S = the perpendicular distance from the point to the light strip, or the projection of the light strip, measured in feet.

L = a length along the light strip in feet. L_1 and L_2 designate specific lengths as shown in Fig. 1.

V angles are always in a plane perpendicular to the light strip. V' measures the lateral tilt of the plane on which the point is located. V angles without superscript are measured from nadir.

U angles are in a plane parallel with the light strip. U' measures the longitudinal tilt of the plane on which the point is located.

Sample Calculations

For instance, to calculate the illumination at the point shown in Case 2, Fig. 1, a typical problem, it is found from the plan and elevation of room (not shown) that:

$$L_1 = 3'$$
$$L_2 = 12'$$
$$S = 5'$$

From the crosswise distribution curve of the fixture, Chart 1, the candlepower at 0° is found to be 1920. The length of the fixture is 4'.

$$I_o = 1920/4 = 480 \text{ c/ft.}$$
$$L_1/S = 3/5 = .60$$
$$L_2/S = 12/5 = 2.40$$

From the *los* curve, Chart 1:

$$Los_o \ .60 = .490$$
$$Los_o \ 2.40 = .675$$
$$Sum = 1.165$$

$$E = \frac{480}{5} \times 1.165 = 112 \text{ ft-c}$$

To calculate Case 9, Fig. 1 using the same data:

$$L_1/S = .60,\ Los_o\ L_1/S = .490$$
$$L_2/S = 2.40,\ Los_o\ L_2/S = .675$$
$$Sum = 1.165$$
$$Sol_o\ L_1/S = .133$$
$$Sol_o\ L_2/S = .310$$
$$\text{Difference} = -.177$$

Let $U' = 20°$, $\cos U' = .940$, $\sin U' = .342$

$$E = 480/5\ [(.940 \times 1.165) - (.342 \times .177)] = 99 \text{ ft-c}$$

Explanation of Formulae

A little study of the formulae in Fig. 1 shows that all are made up of two elements: $E = I/S\ los\ L/S$ and $E = I/S\ sol\ L/S$. The "*los*" equations give the illumination on planes parallel to the source, the "*sol*" equations on planes perpendicular to the source. Both apply directly to sources which end directly over, or opposite the point at which the illumination is to be determined; but by dividing the source into sections, or adding and subtracting imaginary lengths of source they can be used for sources of any length or location. For instance, the formula for Case 2 could have been written $E = E_1 + E_2$, when $E_1 = I/S\ los\ L_1/S$ and $E_2 = I/S\ los\ L_2/S$, and the formula for Case 3 might have been written $E = E_1 - E_2$.

If this rule is strictly followed in the case of "*sol*" formulae, however, the result will give the illumination on both sides of the plane. Since this is seldom desired, it is necessary to disregard that portion of the light source which illuminates the wrong side of the plane.

Laterally tilted planes as shown in Cases 4 and 5 can be taken care of simply by multiplying the basic formulae by the cosine of the angle of tilt. Case 8 is a special case of a twisted perpendicular plane where the same principle can be applied.

TABLE I.—Calculation of *Los* and *Sol* from Lengthwise Distribution Curve Shown on Chart 2.

Calculation of *Los* $I = 1920$

Mid Angle	i = cp	i/I	Constant	Product	Sum = *Los*	Angle u	Tan $u = L/S$
5°	1915	.997	.1736	.1730	.1730	10°	.176
15°	1855	.966	.1684	.1627	.3357	20°	.364
25°	1725	.898	.1580	.1420	.4777	30°	.577
35°	1485	.774	.1428	.1106	.5883	40°	.839
45°	1040	.542	.1232	.0668	.6551	50°	1.192
55°	469	.244	.1000	.0244	.6795	60°	1.732
65°	215	.112	.0737	.0083	.6878	70°	2.747
75°	152	.079	.0451	.0036	.6914	80°	5.671
85°	50	.026	.0152	.0004	.6918	90°	inf.

Calculation of *Sol*

Mid Angle	i = cp	i/I	Constant	Product	Sum = *Sol*	Angle u	Tan $u = L/S$
5°	Same	.997	.0152	.0152	.0152	10°	.176
15°	as	.966	.0451	.0436	.0588	20°	.364
25°	Above	.898	.0737	.0661	.1249	30°	.577
35°		.774	.1000	.0774	.2023	40°	.839
45°		.542	.1232	.0668	.2691	50°	1.192
55°		.244	.1428	.0348	.3039	60°	1.732
65°		.112	.1580	.0177	.3216	70°	2.747
75°		.079	.1684	.0133	.3349	80°	5.671
85°		.026	.1736	.0045	.3394	90°	inf.

Cases 9 and 10, however, require special treatment. In such cases where the plane of measurement is neither parallel with nor perpendicular to the light strip, both *los* and *sol* equations must be used. One way to explain this procedure is as a projection method. In Case 9, for instance, imagine the wedge shown in the figure replaced by a triangular box of the same dimensions. If the area of the lid is one square foot the amount of light falling on it equals the illumination. This quantity of light equals the sum of the lumens which would fall on the inside surfaces of the box if the lid were removed. These quantities can be found by multiplying the illumination on these surfaces, calculated by the formulae for Cases 1 and 6, by the areas of these surfaces, which are equal to cos U' and sin U' respectively. But it is also necessary to subtract the light which is shielded from the bottom of the box by the vertical side. Since this is the quantity of light falling on the outside of the vertical side it can be calculated in the same way as the light on the inside surface.

Like other *sol* formulae, the formulae for Cases 9 and 10 give fictitious results if carried beyond the point where the light source ceases to illuminate the upper surface of the inclined plane and starts lighting up the lower surface.

How to Calculate *Los* and *Sol*

So far it has been assumed that curves giving values of *los* and *sol* are available, either as part of the photometric data for the fixture to be used, or for a similar fixture. Unfortunately it will generally be necessary to calculate *los* and *sol* from a lengthwise distribution curve.

Table I shows the actual calculations required to develop the curves for *los* and *sol* shown on Chart 2 from the lengthwise distribution curve at the top of Chart 2. The procedure is as follows:

First, divide all 5° candlepower values, the readings at 5°, 15°, 25°, etc., up to 85°, by the candlepower at 0°.

Next, multiply each by the proper constant as given in Table I.

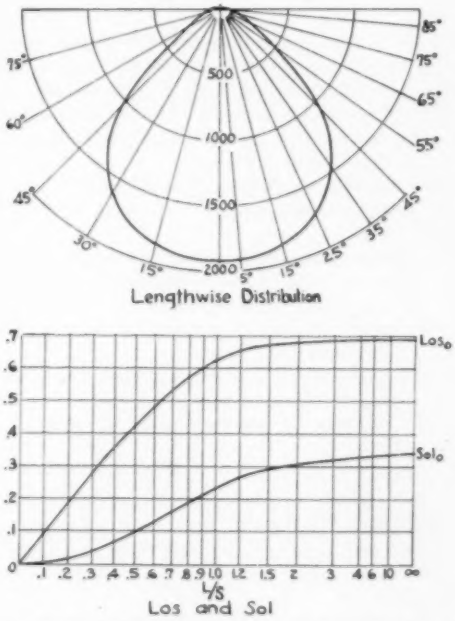


Chart 2. Lengthwise distribution curve of same luminaire showing the Los_0 and Sol_0 curves calculated in Table I.

Next, add progressively.

Finally, plot the sums in terms of tangents of the 10° angles, also shown in Table I.

Some General Considerations

Although developed primarily for calculating illumination from long continuous rows of fluorescent units, this method of calculation will give satisfactory results when applied to discontinuous rows, or to lines of incandescent sources if the patterns of adjacent units overlap. In doing this, however, care must be taken to use the average candlepower per foot of row, instead of per foot of fixture. For instance, suppose the line of light shown in Case 1, Fig. 1, were replaced by a row of incandescent units spaced three feet apart. The candlepower of a single unit at 0° is found to be 820. Then $I_o = 820/3 = 273$. A *los* curve for the incandescent unit would, of course, be required to make the calculation.

This method can be applied only to direct illumination from linear sources. It does not take into consideration light reflected from ceilings, walls, or anywhere else. Illumination by reflected light is often a large portion of the total illumination and should not be neglected, but this method is not intended for such calculations. It is particularly useful for figuring local lighting on work benches, control boards, displays, show cases and show windows. It can also be used for estimating gradients in rooms lighted with direct lighting units, particularly to determine the arrangement and spacing of the units.

Derivation of Functions and Formulae

Derivation of Los

Refer to Fig. 2 while an elementary text-book problem is reviewed.

The illumination on the point "*P*" from a very short section of the light source, *dl*, is:

$$dE = \frac{i_u}{S^2}\cos^3 u\, dl$$

$$l = S\tan u$$

$$dl = \frac{S}{\cos^2 u}\, du$$

$$dE = \frac{i_u}{S}\cos u\, du$$

$$E = \frac{l}{S}\int i_u \cos u\, du$$

At this point the text-books make the assumption that $i_u = I_o \cos u$., thus departing somewhat from reality and making the practical solution of the problem no simpler. Instead, it is proposed to evaluate the integral directly from data on the actual fixture under consideration. To simplify interpolation, however, it is desirable to change the equation slightly, taking the perpendicular candlepower out of the integral, thus:

$$E = \frac{I_o}{S}\int \frac{i_u}{I_o}\cos u\, du$$

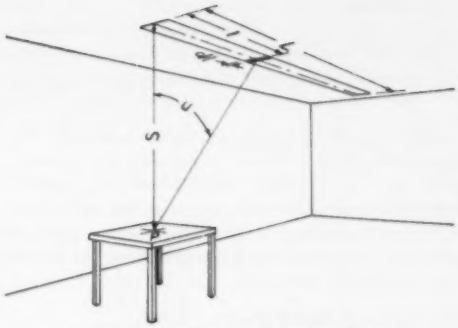


Figure 2. Diagram for derivation of *Los*.

And, it is proposed, let

$$los\,\frac{L}{S} = \int_{u=0}^{u=\tan^{-1} L/S} \frac{i_u}{I_o}\cos u\, du$$

Then, in this example, Fig. 2:

$$E = \frac{I_o}{S}\, los\,\frac{L}{S}$$

Evaluation of Los

The problem now becomes the evaluation of *los* when:

$$los\ L/S \text{ or } los\ U = \int_{u=0}^{u=U=\tan^{-1} L/S} \frac{i_u}{I_o}\cos u\, du$$

(For convenience *los U* is used instead of the longer expression *los* tan *U*.)

This can be done by following the same method which has been used for many years to determine zone lumens. The integral must be evaluated from $L/S = 0$ *to* $L/S = \infty$; that is, from $U = 0°$ to $U = 90°$. Customarily this 90° is divided into nine zones of 10° each, $(\Delta U = 10°)$ and it is assumed that the candlepower, i_u, is constant throughout the 10° zone, and equal to the candlepower in the middle of the zone $[i_u = i_{(u + \frac{1}{2}\Delta u)}]$.

If this assumption is made, the increment of *los* in the zone from *U* to $(U + \Delta U)$ is:

$$los\,(U+\Delta U) - los\,U = \frac{i_{(u+\frac{1}{2}\Delta u)}}{I_o}\int_{u=U}^{u=U+\Delta U}\cos u\, du$$

Integrating,

$$los\,(U+\Delta U) - los\,U = \frac{i_{(u+\frac{1}{2}\Delta u)}}{I_o}(\sin\,(U+\Delta U) - \sin U)$$

$(\sin\,(U+\Delta U) - \sin U)$ is the *los* constant. The increment of *los* is found by multiplying this constant by the mid-zone candlepower. By adding these increments the value of *los* at the end of any zone may be found. If these values are plotted, as shown in Charts 1 and 2, intermediate values can be scaled from the curve.

Explanation of Case Formulae

The formula for Case 1 has been explained in the process of deriving the function *los*. Cases 2 and 3 are self-evident. Cases 4 and 5 show the need for *los* curves at various lateral angles and for a slightly more general definition of *los* than that given above, namely:

$$los_v\,L/S = \int_{u=0}^{u=\tan^{-1}L/S} \frac{i_{uv}}{I_v}\cos u\,du$$

The method of derivation and evaluation of los_v is the same as of los_o but the candlepowers are measured at an angle "V" from nadir.

Derivation of Sol

Case 6 brings in the inverse function of *los*, "*Sol*." It is derived the same way as *los* so the explanation will be somewhat abbreviated. Refer to Fig. 3.

$$dE = \frac{i_u}{S^2}\cos^2 u \sin u\,dl$$

$$E = \frac{I_o}{S}\int \frac{i_u}{I_o}\sin u\,du$$

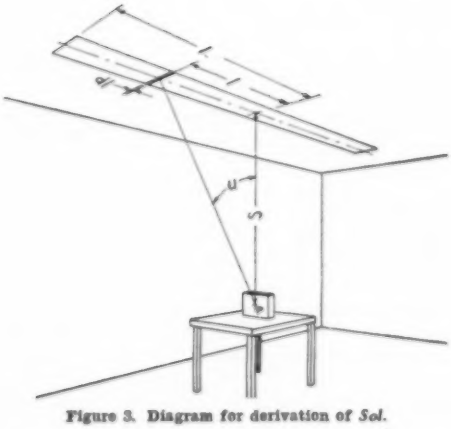


Figure 3. Diagram for derivation of *Sol*.

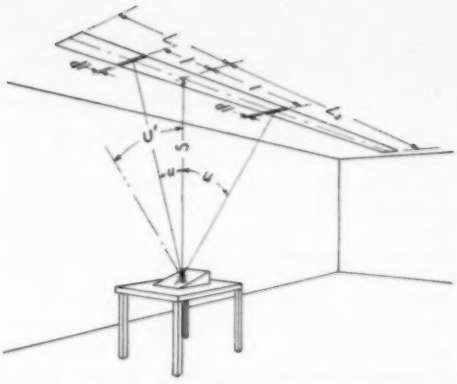


Figure 4. Diagram for derivation of formula for illumination on inclined plane.

$$\text{Let } sol\,L/S = \int_{u=0}^{u=\tan^{-1}L/S} \sin u\,du$$

$$E = \frac{I_o}{S}\,\text{sol}\,L/S$$

Sol is evaluated in the same way as *los* except that in this case the *sol* constants are figured by the formula, $\cos U - \cos\,(U+\Delta U)$.

Case 6 is thus explained and Cases 7 and 8 follow as self-evident corollaries.

General Formula

Case 9 requires another retreat to first principles. This is the case of the tilted plane shown in Fig. 4. The illumination from the nearer part of the light source can be evaluated by the following equation:

$$E_1 = \frac{I_o}{S^2}\int \frac{i_u}{I_o}\cos\,(U'-u)\cos^2 u\,dl$$

$$E_1 = \frac{I_o}{S}\int \frac{i_u}{I_o}\cos\,(U'-u)\,du$$

$$E_1 = \frac{I_o}{S}\int \frac{i_u}{I_o}\,(\cos U'\cos u + \sin U'\sin u)\,du$$

$$E_1 = \frac{I_o}{S}\left[\cos U'\int \frac{i_u}{I_o}\cos u\,du + \sin U'\int \frac{i_u}{I_o}\sin u\,du\right]_{u=0}^{u=\tan^{-1}L/S}$$

$$E_1 = \frac{I_o}{S}\,[\cos U'\,los\,L_1/S + \sin U'\,sol\,L_1/S]$$

In like manner, the illumination from the farther part of the source is:

$$E_2 = \frac{I_o}{S} \int \frac{i_u}{I_o} \cos (U' + u) \cos^2 u \, dl$$

$$E_2 = \frac{I_o}{S} \left[\cos U' \, los \, L_2/S - \sin U' \, sol \, L_2/S \right]$$

The total illumination, $E = E_1 + E_2$

$$E = \frac{I_o}{S} \left[\cos U' \, (los \, L_1/S + los \, L_2/S) + \sin U' \, (sol \, L_1/S - sol \, L_2/S) \right]$$

If the plane is also tilted in the other direction by an angle V' as shown in Case 10, the illumination on the parallel projection of the plane is reduced by cos V' while the illumination on the perpendicular projection remains unchanged.

The general formula, Case 10, is, therefore:

$$E = \frac{I_o}{S} \left[\cos U' \cos V' \left(los \frac{L_1}{S} + los \frac{L_2}{S} \right) + \sin U' \left(sol \frac{L_1}{S} - sol \frac{L_2}{S} \right) \right]$$

Approximation Inherent in This Method of Calculation

In this method of calculation, as in nearly all lighting calculations, certain approximations have been made, which, although common enough, should be stated.

First, there is the supposition that the source of light is a true line, that its width is zero, which of course never is true. Neither are there any true point sources, but a fixture 12 or fifteen inches in diameter at a distance of six or seven feet is ordinarily considered a point source for point by point calculation. The error due to treating an ordinary fluorescent fixture as a line source is of comparable magnitude. Nevertheless, if the fluorescent fixture were within two or three feet of the point of measurement the proposed method of calculation would not give accurate results. The luminaire would have to be considered as an area source of unequal brightness.

Second, it has been assumed that each foot of luminaire produced the same amount of light and the same candlepower distribution as every other foot. This is definitely not true. Actually the average candlepower distribution has been assumed typical and it is quite likely that no particular one-foot section of the fixture would give exactly this average distribution. As a result, if an illumination gradient curve is calculated according to this method and then the actual illumination measured in a laboratory, bumps and depressions appear in the measured curve which do not show in the calculated curve. This is particularly true if this method is used to calculate the illumination from a row of incandescent fixtures. It is doubtful, however, whether anyone is interested in these small bumps, so long as the average figures are correct.

Other Uses for "*Los*" and "*Sol*"

Light on a Strip from a Point Source

Most lighting equations are reversible. This is true of the formulae in the first part of this paper. If the illumination at a point from a strip of light is:

$$E = \frac{I}{S} \left(los \frac{L_1}{S} + los \frac{L_2}{S} \right)$$

then the amount of light on a narrow strip from a single point source is:

$$F = W \frac{I}{S} \left(los \frac{M_1}{S} + los \frac{M_2}{S} \right)$$

F = Lumens on strip
W = Width of strip in feet
I = Perpendicular candlepower toward strip
S = Shortest distance from strip to light source in feet
M = Length of strip in feet

This can be worked out from first principles as follows:

If the strip is narrow, the amount of light striking any small section of it can be closely approximated by multiplying the illumination at the center by the area of the section. As shown in Fig. 5, the area of a small section of the strip is $W\,dm$. The illumination at the center of this area is $\frac{i_u}{S^2} \cos^3 u$. The sum of the light striking all these

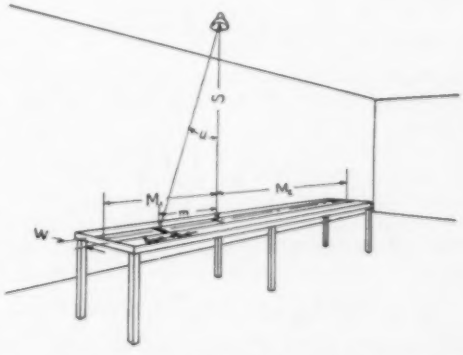


Figure 5. Diagram for derivation of formulae for quantity of light on strip from a point source.

small portions gives the amount of light striking the whole strip.

$$F = W \int \frac{i_u}{S^2} \cos^3 u \, dm \qquad dm = \frac{S}{\cos^2 u} du$$

$$F = W \frac{I}{S} \int_{u=\tan^{-1}\frac{M_1}{S}}^{u=\tan^{-1}\frac{M_1}{S}} \frac{i_u}{I} \cos u \, du$$

$$F = W \frac{I}{S} \left(los \frac{M_1}{S} + los \frac{M_2}{S} \right)$$

In like manner, other formulae in the first part of this paper can be applied backward to give the quantity of light which will fall on a strip from a point source. This is a useful method for determining the utilization of specialized luminaires such as street lights, control board lights, counter or bench lights and other forms of asymmetric lighting equipment.

Light on a Strip from a Long Source

Los and *sol* can be integrated, thus making it possible to develop formulae for finding the quantity of light on a strip from a long, linear source. The simplest case is that of a strip exactly as long as the light source and directly beneath it, as shown in Fig. 6. Following the same procedure as in the previous problem:

Let e = illumination at point p.

$$e = \frac{I}{S} \left(los \frac{m}{S} + los \frac{L-m}{S} \right)$$

$$F = W \int e \, dm = W \frac{I}{S} \int \left(los \frac{m}{S} + los \frac{L-m}{S} \right) dm$$

$$\int los \frac{m}{S} dm = m \, los \frac{m}{S} - \int m \, d \, los \frac{m}{S}$$

$$= m \, los \frac{m}{S} - \int m \frac{i_u}{I} \cos u \, du$$

$$\text{when } \frac{m}{S} = \tan u, \; m = S \frac{\sin u}{\cos u}$$

$$= m \, los \frac{m}{S} - S \int \frac{i_u}{I} \sin u \, du$$

$$(1) \qquad \int los \frac{m}{S} dm = m \, los \frac{m}{S} - S \, sol \frac{m}{S}$$

$$\int los \frac{L-m}{S} dm = m \, los \frac{L-m}{S} - \int m \, d \, los \frac{L-m}{S}$$

$$= m \, los \frac{L-m}{S} - \int m \frac{i_u}{I} \cos u \, du$$

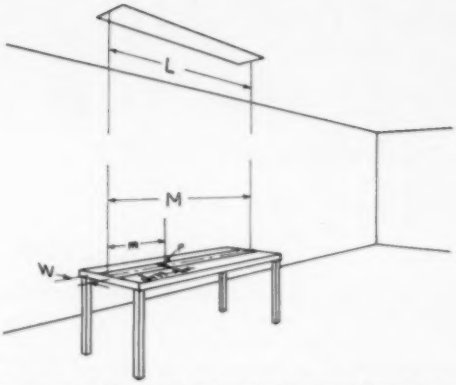


Figure 6. Diagram for derivation of special formula for quantity of light on strip from line source.

$$\text{when } \frac{L-m}{S} = \tan u, \; m = L - s \frac{\sin u}{\cos u}$$

$$= m \, los \frac{L-m}{S} - L \int \frac{i_u}{I} \cos u \, du$$

$$+ S \int \frac{i_u}{I} \sin u \, du$$

$$(2) \qquad \int los \frac{L-m}{S} dm = m \, los \frac{L-m}{S} - L \, los \frac{L-m}{S}$$

$$+ S \, sol \frac{L-m}{S}$$

Adding (1) + (2)

$$F = W \frac{I}{S} \left[m \, los \frac{m}{S} - S \, sol \frac{m}{S} - (L-m) \, los \frac{L-m}{S} + S \, sol \frac{L-m}{S} \right]_{m=0}^{m=L}$$

$$F = W \frac{I}{S} \left[L \, los \frac{L}{S} - S \, sol \frac{L}{S} + L \, los \frac{L}{S} - S \, sol \frac{L}{S} \right]$$

$$F = 2 I W \left[\frac{L}{S} los \frac{L}{S} - sol \frac{L}{S} \right]$$

or

$$F = 2 I W \left[\frac{M}{S} los \frac{M}{S} - sol \frac{M}{S} \right]$$

This is the formula for the quantity of light falling on a strip from a linear source of the same length and directly above it. As will be shown, it can also be used to find the amount of light falling on a strip from a linear source which is neither

the same length nor directly above it as shown in Fig. 7.

Divide the problem shown in Fig. 7 into two parts:

Let F_1 = The quantity of light falling on length of strip M_1

Let F_2 = The quantity of light falling on length of strip M_2

$$F_1 = W\frac{I}{S}\int\left(los\frac{L+m_1}{S} - los\frac{m_1}{S}\right)dm_1$$

$$F_2 = W\frac{I}{S}\int\left(los\frac{L-m_2}{S} + los\frac{m_2}{S}\right)dm_2$$

Following the same procedure as before it is found that:

$$F_1 = I\,W\left[\left(\frac{L+M_1}{S}los\frac{L+M_1}{S} - sol\frac{L+M_1}{S}\right) - \left(\frac{M_1}{S}los\frac{M_1}{S} - sol\frac{M_1}{S}\right) - \left(\frac{L}{S}los\frac{L}{S} - sol\frac{L}{S}\right)\right]$$

$$F_2 = I\,W\left[\left(\frac{L}{S}los\frac{L}{S} - sol\frac{L}{S}\right) + \left(\frac{M_2}{S}los\frac{M_2}{S} - sol\frac{M_2}{S}\right) - \left(\frac{L-M_2}{S}los\frac{L-M_2}{S} - sol\frac{L-M_2}{S}\right)\right]$$

$$F = F_1 + F_2 = I\,W\left[\left(\frac{L+M_1}{S}los\frac{L+M_1}{S} - sol\frac{L+M_1}{S}\right) - \left(\frac{M_1}{S}los\frac{M_1}{S} - sol\frac{M_1}{S}\right) + \left(\frac{M_2}{S}los\frac{M_2}{S} - sol\frac{M_2}{S}\right) - \left(\frac{L-M_2}{S}los\frac{L-M_2}{S} - sol\frac{L-M_2}{S}\right)\right]$$

Now suppose that both the source and the strip were extended, as shown by the dotted lines in Fig. 7, until both were of equal length and the one was directly above the other. Divide this figure into sections A, B and C as shown. If F_A, F_B, etc., are understood to represent the light falling on a strip from a source of the same length and directly above it as shown in Fig. 6, then the terms of the above equation are found to equal:

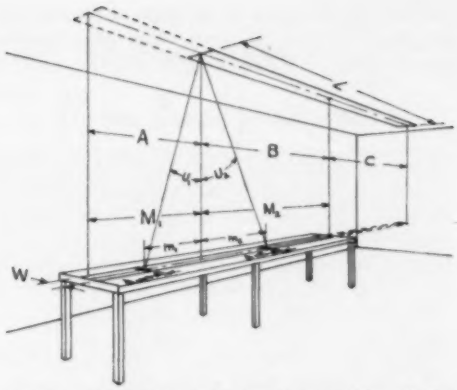


Figure 7. Diagram for derivation of general formula for quantity of light on strip from line source.

1st Term

$$+ I\,W\left(\frac{L+M_1}{S}los\frac{L+M_1}{S} - sol\frac{L+M_1}{S}\right) = +\tfrac{1}{2}F_{(A+B+C)}$$

2nd Term

$$- I\,W\left(\frac{M_1}{S}los\frac{M_1}{S} - sol\frac{M_1}{S}\right) = -\tfrac{1}{2}F_A$$

(Imaginary Source, Real Strip)

3rd Term

$$+ I\,W\left(\frac{M_2}{S}los\frac{M_2}{S} - sol\frac{M_2}{S}\right) = +\tfrac{1}{2}F_B$$

(Real Source, Real Strip)

4th Term

$$- I\,W\left(\frac{L-M_2}{S}los\frac{L-M_2}{S} - sol\frac{L-M_2}{S}\right) = -\tfrac{1}{2}F_C$$

(Real Source, Imaginary Strip)

In other words, to find the amount of light falling on a strip from a linear source equalize the lengths of strip and source by adding imaginary sections. From half the light which would fall on the whole strip, both real and imaginary, from the whole source, both real and imaginary, subtract half the light in any section which contains either an imaginary strip or source, and add half the light in any section where both strip and source are real.

$$F = F_{(A+B+C)} - F_A + F_B - F_C$$

These examples, Figs. 5, 6 and 7, have all shown the strip beneath the source. If displaced or tilted laterally, it is merely necessary to multiply the

formulae by the cosine of the angle of tilt and use the proper *los* and *sol* curves. The basic formula then becomes:

$$F = 2I_v\, W \cos V' \left(\frac{M}{S} los_v \frac{M}{S} - sol_v \frac{M}{S} \right)$$

Thus the amount of light falling from a linear source can be calculated, if the strip is parallel to the source. The formulae apply to strips on walls parallel to the source as well as to strips parallel to the floor and so can be used to find the amount of light falling on control boards or chalkboards. It is believed that they will take care of most cases where such calculations are required.

Other uses for *los* and *sol* may be found. They might well be useful in photometry, both for determining the output of asymmetric fixtures and for finding correction factors for too short test distance, but this field has been only partly explored.

In the preparation of this paper the help and constructive criticism of the engineering staff of the Holophane Company have been invaluable. Particularly, Kurt Franck, Ruland Smith, and Herbert Odle contributed greatly to the difficult task of developing an idea into an integrated article.

Bibliography

1. Pole, Joseph C.: *Transactions of the Illuminating Engineering Society*, Vol. VI, p. 312 (1911).

2. Higbie, H. H.: "Prediction of Illumination at a Point from a Source of Any Shape," ILLUMINATING ENGINEERING, Vol. XXXVI, p. 79 (January 1941).

3. Moon, P. G.: "Scientific Basis of Illuminating Engineering," McGraw Hill Book Co., Inc., New York, 1936, Chapter 10.

4. Higbie, H. H.: "Lighting Calculations," John Wiley & Sons, Inc., New York, 1934, Chapter 6.

5. Wakefield, E. H.: "A Simple Graphical Method of Finding Illumination Values from Tubular, Ribbon, and Surface Sources," ILLUMINATING ENGINEERING, Vol. XXXV, p. 142 (February 1940).

6. Wakefield, E. H., and McCord, Campbell: "Illumination Distribution from Linear Strip and Surface Sources," ILLUMINATING ENGINEERING, Vol. XXXVI, p. 1330 (December 1941).

7. Franck, Kurt: "Performance Evaluation of Fluorescent Units," ILLUMINATING ENGINEERING, Vol. XXXVII, p. 217 (April 1942).

8. Spencer, D. E.: "Exact and Approximate Formulae for Illumination from Troffers," ILLUMINATING ENGINEERING, Vol. XXXVII, p. 596 (November 1942).

9. Burnham, Robert D.: "The Illumination at a Point from an Industrial Fluorescent Luminaire," ILLUMINATING ENGINEERING, Vol. XLV, p. 753 (December 1950).

DISCUSSION

ARTHUR A. BRAINERD*: This method of calculating direct illumination from linear sources is both ingenious and interesting. From the very nature of the system, it is obvious that it was developed primarily for the purpose of predicting the illumination characteristics of a luminaire in the process of design.

For this purpose the new system should be quite valuable, particularly for the design of lighting equipment involving a very precise and accurate control of light flux. Since no consideration is given to the contribution of redirected light flux, it is hard to see just how the method could be used in the calculation of a lighting system.

In general, the suggestion involves a degree of precision not justified by its low degree of accuracy.

R. G. MCPHAIL**: Mr. Brainerd's comments are much appreciated. It is hoped that greater accuracy may be attainable by the use of this method of calculation; but, if so, it is a by-product. The main advantage of the system is that it is quick and easy to use. The author used it for about two years while engaged in installation design, primarily as a labor-saving device.

Of course, as Mr. Brainerd points out, this method can be used only to calculate direct illumination. It will do for line sources exactly the same job as the inverse square system of calculation will do for point sources. If either is used, it is necessary to estimate or calculate the illumination from reflected light by some other method.

*Philadelphia Electric Co.
**Author.

Errata

In the footnote on page 472 of the September issue of ILLUMINATING ENGINEERING an error was made in reporting the company affiliation of Mr. H. L. Logan and Mr. A. W. Lange. This should have read "Authors: Holophane Company, New York, N. Y."

Lighting a Carpet Showroom

LIGHTING OBJECTIVE: To produce a moderate level of general illumination similar to home lighting.

Installation at Zandt Carpet Company, 1122 N. Vine Street, Hollywood, California; lighting designed by Stiles Clements.

General Information: The 120 x 70 x 16 foot sales area is decorated as follows:

Ceiling	green acoustical tile	20% RF
Walls		
front	green	20% RF
rear	beige	63% RF
Floor	gray-beige carpet	38% RF
Rug racks	blond wood	67% RF

Lighting Installation: Twenty-three special Light Control Company flush-mounted, louvered, 6-foot square luminaires are installed on 16-foot centers. Each unit contains four 72-inch, T-8, 200-ma, 4500K white fluorescent lamps. See Figure 2. The ballasts are installed remotely.

Ninety-two recessed flush units containing 150-watt R-40 reflector floodlamps are mounted on 8-foot centers (about one foot from corner of each fluorescent unit).

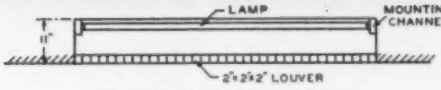


Figure 2. Luminaire cross-section.

Resultant illumination and brightness values are indicated below:

Illumination		
Fluorescent luminaires only	14	ft-c
Both lighting systems operating	22	ft-c
Brightnesses		
Fluorescent luminaires		
30° from ceiling line	90	ft-L
45° from ceiling line	110	ft-L
Ceiling	1.6	ft-L
Walls		
front	2.0	ft-L
rear	7.0	ft-L
Rug racks		
top	12	ft-L
side	5.5	ft-L
Floor	6.5	ft-L

Lighting data submitted by Roy H. Kreyser, Department of Water and Power, City of Los Angeles as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society 1860 Broadway, New York 23, N. Y.

A.I.A. File No. 31

Maintenance of Industrial Lighting

By C. E. EGELER
R. F. VANDEN BOOM

ILLUMINATING engineers, and to a lesser extent, consumers of light in industry, have long realized the gradual but serious cumulative loss in illumination resulting from dirt on lamps and reflectors. Most manufacturers simply are not aware that where there is no regular cleaning, the light loss may be as much as 50 per cent. This is no doubt due in part to the paucity of actual test data regarding the rate of depreciation in lighting levels which occurs under various service conditions and to the limited dissemination of such information as is available. Plant management everywhere needs such information.

Over 25 years ago Ketch and Anderson[1] published test figures based on depreciation tests of filament lamps in industrial and commercial areas; and early in World War II Gaetjens[2] published the results of a survey which embraced twenty-seven war plants, all but four using fluorescent lamps. His data showed a decrease in illumination from all causes, including dirt, of 34 per cent, even though the installations had been in service for an average of *less than three months*. Dirt collection was responsible for half this loss. In the matter of depreciation in light output per thousand hours inherent in the lamps themselves there has been some improvement in the intervening years.

More complete information on rates of depreciation is needed in the design of new lighting systems as well as in the formulation of an engineering basis for the choice of a maintenance factor. The rate of depreciation in output of a lighting system is a major factor in the initial investment and the operating cost for a given illumination value.

Defense mobilization imposes on industry an imperative responsibility for the most effective use of production facilities and manpower. Good lighting becomes more vital than ever, particularly when it is remembered that in the increment of needed workers there will be a greater proportion of older people who need the higher illumination levels to compensate for impairment of vision with age. Unnecessary loss of light, therefore, should not be tolerated.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: General Electric Co., Nela Park Engineering Division, Cleveland, Ohio.

Among the principal factors affecting the light losses are the following:

Lamp type—inherent rate of depreciation
Burning hours
Luminaire design—ventilation, reflector material and contour
Temperatures—ambient, reflector, lamp
Prevalence of dust and fumes
Operating voltage at lamp
Deterioration of finishes and reflectance of surroundings
Cleaning—methods and schedules

To add to the available data on loss due to dust the authors have undertaken tests in some 13 factory areas in two industrial cities, representing different degrees of cleanliness or dirt prevalence. The tests were made on individual lighting units already in service, and on control luminaires added in most areas.

To facilitate measurement of the output of fluorescent units the test equipment shown in Fig. 1 was developed. Its use involves no disturbance of the luminaires. A specially calibrated cosine and

Figure 1. Light cells suspended two feet below luminaires were used to measure relative light output.

color-corrected light-cell assembly is mounted on the platform to measure footcandle values at two feet below the luminaire. This position was adopted after ascertaining that for a unit of the RLM type the reading at this location is closely proportional to total output of the luminaire. Light meter readings were taken with the lamps first on, and then off; the difference is the illumination contributed by the test luminaire alone.

A timer to measure burning hours and a counter to determine number of lamp starts were installed in each area. Also, facilities for adjusting the impressed line voltage to 118 volts were included in most of the luminaires.

The existing lighting equipment had not been cleaned for a number of years. The output was measured initially as follows:

(1) As found—with dirty lamps in dirty reflector
(2) With comparison standard lamps in dirty reflector
(3) With comparison standards in cleaned reflector
(4) With new lamps installed in cleaned reflector.

The overall increase in illumination for step (2) in comparison with step (1) may be assumed to represent the depreciation from dirt plus the loss in lamp output at half life. The lamps had been replaced individually as they failed over these several years and thus on the average they had burned about 50 per cent of inherent life. The average effect of dirt on the lamp can be approximated by deducting the depreciation of the lamp itself at half life as determined by laboratory life tests for the types of lamps employed.

Following the initial measurements, data were taken every month without disturbing the luminaires. Eventually the installations will be restored to the conditions of clean reflectors and lamps, and measurements will cover the following:

(1) Lighting units as found—dirty lamps and reflectors
(2) Dirty lamps cleaned and replaced in dirty reflector
(3) Lamps replaced with comparison standards in dirty reflector
(4) Reflector cleaned—comparison standards used in clean reflector

In most of the areas control luminaires of uniform characteristics were installed to provide a common denominator for the comparison of various conditions. They are two-lamp, 40-watt, conventional open-end industrial luminaires with synthetic enamel finish.

Gain on Initial Cleaning

The heavy penalty suffered in factory areas due to lack of maintenance is shown by the "before" and "after" data on Table I. An average light loss of 53 per cent overall was found in the six plant areas where maintenance had been neglected. Dirt on the lamps alone accounted for an average loss of 19 per cent, while that on the reflectors was responsible for a 28 per cent reduction in delivered light.

Rate of Depreciation

Individual departments vary widely in the amount of dirt present, and this is reflected in the rates of light loss in the control units, as shown in Table I. In the foundry the rate of depreciation due to dirt alone was approximately three times that in the heavy machine shop and ten times that found in the woodworking shop.

TABLE I.—Rate of Depreciation of Illumination in Industrial Areas.

Area	Luminaire Type and Finish	No. of Luminaires	Average Burning Hours Per Month	As Found	After Relamping Only	After Cleaning & Relamping	Light Output After Subsequent Service Without Cleaning				And After Deducting Lamp Depreciation			
							1 mo.	2 mo.	3 mo.	4 mo.	1 mo.	2 mo.	3 mo.	4 mo.
Low-Bay Areas														
Woodworking	2-40W Synthetic	3	325	53%	69%	100%	89%	84%	82%	77%	99%	98%	97%	94%
Laboratory	2-40W Synthetic	2[a]	250	—	—	100	88	87	83	76	—	—	—	98
"	2-40W Porcelain	2	250	53	79	100	92	91	85	80	—	—	—	—
Core Room	2-85W Porcelain	2	200	35	57	100	79	69	66	54	86	77	76	65
Engine Assembly A	2-40W Porcelain	2	375	69	88	100	77	64	58	57	86	75	71	71
Engine Assembly B	2-85W Porcelain	2	200	41	77	100	83	73	68	65	90	82	79	77
Office	2-40W Synthetic	1[a]	180	—	—	100	96	89	86	73	—	—	98	86
"	1-40W Aluminum	2[a]	180	62	97	100	96	93	89	81	—	—	—	95
High-Bay Areas														
Foundry	2-40W Synthetic	2[c]	250	—	—	100	60	54	52	44	66	62	61	59
"	2-40W Porcelain	2	250	—	—	100	70	62	57	54	77	72	67	66
"	2-85W Porcelain	2	250	28	68	100	63	58	52	48	70	67	61	58
Warehouse	2-40W Synthetic	1[a]	600	—	—	100	89	88	86	76	—	—	—	98
Welding	2-40W Synthetic	2[a]	250	—	—	100	79	70	65	61	86	79	76	74
Machine Shop (Heavy)	2-40W Synthetic	2[a]	175	—	—	100	88	82	77	71	94	91	88	83

[a] Control luminaires of the RLM type.
[c] Single-lamp aluminum troffers.
All other industrial luminaires of the RLM type.

In the foundry, the test included both 2-lamp 40-watt and 2-lamp 85-watt porcelain enameled luminaires in addition to the synthetic enameled control units.

For all luminaires except those in the office area, the average drop in output from the clean-reflector, new-lamp condition at the end of only three months was 31 per cent. After deducting lamp depreciation, the loss in three months due to dirt collection alone was 3 per cent in the woodworking shop, 37 per cent in the foundry, 12 per cent in the heavy machine shop, 24 per cent in the welding shop, and 29 per cent and 21 per cent for the two types of units in the engine assembly area. The conditions prevailing are typical of those encountered in industries of these several types.

As shown by the Table I and the curve of Fig. 2, the rate of depreciation is greatest immediately after cleaning. The slope of the curve decreases and eventually it becomes asymptotic. While this condition had not been reached in the period covered by the tests here reported it has been demonstrated by Gaetjens.[3] The dotted line extensions of the curves show the approximate ultimate values, which will be checked as the tests are continued through a long period.

The office was lighted by single-lamp 40-watt aluminum troffers; the control unit, however, was the common RLM 2-lamp industrial luminaire. The results show that the aluminum troffer has excellent maintenance characteristics. This was anticipated when the test was begun since only a 3 per cent increase in illumination resulted when the troffers were cleaned for the first time in several years.

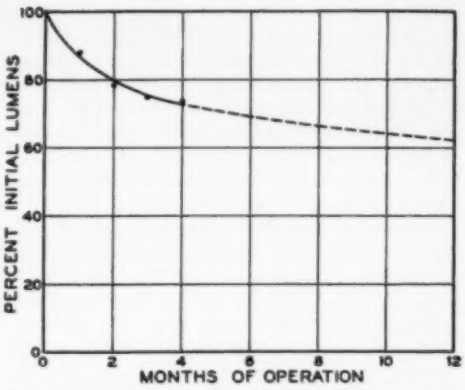


Figure 2. Depreciation rate of light output due to luminaire dirt in engine assembly area.

Economic Value of Planned Maintenance

If the amount of light lost during a given period is known, the economic value of cleaning can be determined, using energy and labor costs applying for the plant in question. Taking the engine assembly area as a typical example, the average loss due to dirt collection was 25 per cent at the end of 3 months, with about 31 per cent indicated (Fig. 2) at the end of 6 months. Without cleaning, the loss will approach 45 per cent. Even if the luminaires are cleaned only once in six months there would thus be a gain in illumination of about 42 per cent above the asymptotic value.

The operating cost of a lighting system always involves energy, lamp and lamp replacement (labor) costs. In a typical medium-sized plant with

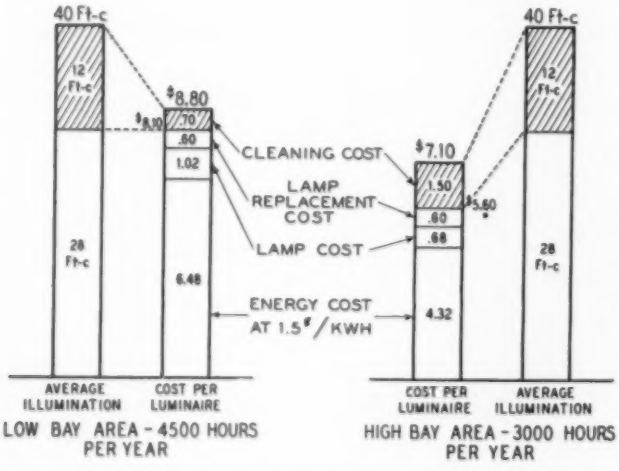


Figure 3. Cross-hatched portions show added annual operating costs and illumination increases for two cleanings per year — two-lamp 40-watt fluorescent industrial luminaires.

energy at 1½¢ per kwhr, 85¢ net cost for a 40-watt fluorescent lamp, a 50¢ cost of random lamp replacement, and 4500 burning hours per year, the overall annual operating cost is $8.10 per 2-lamp luminaire, as shown by the chart of Fig. 3. Two cleanings per year will provide a 42 per cent increase in illumination, or $3.40 worth of light. For a given average illumination the required investment will likewise be substantially reduced. Even though this investment factor be ignored, any cleaning cost up to $1.70 per fixture pays a real dividend.

Although cleaning costs vary widely, reports from plant engineers and lighting maintenance companies indicate that in a low-bay area, such as the above engine assembly department, systematic cleaning of industrial luminaires with two 40-watt fluorescent lamps can be done for about 35¢ each. Based on this cleaning cost, the bars at the left of the chart, Fig. 3, show that an additional operating expense of only 9 per cent, or 70¢, yields a $3.40 return in added illumination.

In the engine assembly area, as is often the case, more frequent cleaning could produce an even greater net gain. If group replacement of lamps were coordinated with the cleaning schedule, the reduction in lamp replacement labor cost would offset the added lamp cost, and further benefits would result.

In high-bay areas cleaning costs are usually greater and are largely dependent upon the accessibility of the lighting equipment. Neglecting extreme cases, a typical range for cleaning high-bay fluorescent luminaires, is 25¢ to $1.00. Seldom will the cost of systematic cleaning equal the corresponding gain — to say nothing of the effect on initial investment. Using a 75¢ cleaning cost, 85¢ net lamp cost, a 75¢ lamp replacement cost, 1½¢ per kwhr energy rate and 3000 burning hours per year, Fig. 3 (right) shows that in the welding shop a maintenance schedule of two cleanings per year should provide 41 per cent average increase in illumination for an additional operating cost of 27 per cent.

With fewer burning hours, or lower energy rates, the gain of cleaning becomes less. For example, if the lamps in the engine assembly area were operated only 2500 hours per year (single-shift operation) and the energy rate had been 1¢ per kwhr the 42 per cent increase in illumination from cleaning would have been realized from a 21 per cent increase in operating cost.

On the other hand, the dirt conditions in many locations naturally are worse than in the above engine assembly area, and systematic maintenance may provide an increase of 70 per cent or more in illumination for an additional cost of 10 to 15 per cent.

References

1. Anderson, E. A. and Ketch, J. M.: "Depreciation of Lighting Equipment Due to Dust and Dirt," *Transactions of the Illuminating Engineering Society*, p. 55 (January 1924).
2. Gaetjens, A. K.: "Lighting Maintenance in War Industry Plants," *Transactions of the Illuminating Engineering Society*, p. 403 (1942).
3. Gaetjens, A. K.: "A Guide to Realistic Maintenance Factors for Lighting Installations, ILLUMINATING ENGINEERING, p. 307 (May 1945).

DISCUSSION

FRED J. VORLANDER*: The accumulation of data presented in this paper is a forceful illustration of what actually happens to a lighting system when maintenance of lamps and fixtures is neglected. It illustrates again what has been said so many times in the past about the need for properly maintaining lighting systems. Unfortunately, however, such data, important as they are, rarely are applicable to any other installation than the explicit cases discussed, for every lighting installation is different in its depreciation values and economics. Even the same area will vary appreciably from season to season depending upon the type and amount of work done, the number of people active in the area, the type of exposure, and the number of hours the equipment is in and out of operation. For purposes of consumer use, therefore, the data shown in Figures 1 and 2 (of the paper) are limited to the specific cases discussed.

Some of the data and statements contained in this paper were difficult to understand. For instance, reference is made to the use of a "comparison standard lamp." The meaning of this term is not clear, but I expect it is a lamp whose characteristics were known to fall within certain tolerances.

In the data shown in Table I, it is rather difficult to compare some of these operating conditions because the data presented were taken at a variety of periods in lamp life for which the rate of lamp depreciation varies widely.

Figure 2 was based on only four months of tests, yet the curve was presumed to follow asymptotic tendencies as previously discussed by Gaetjens in reference (3) of this paper. However, Figure 2 is based on fixtures other than those of the control groups. When the three control groups shown with complete data are considered, they obviously depart from asymptotic characteristics by having more severe depreciation in the fourth month than in the previous third month. In fact, averages of monthly values for all nine complete sets of data shown in Table I also show a more severe downward trend in depreciation the fourth month than in the previous month.

We must bear in mind that the asymptotic curves referred to in Gaetjens' paper were the result of no fixture maintenance other than that which was created by replacing a dirty burned-out lamp with a new clean lamp. If the tests discussed in this paper were to be continued without any fixture cleaning, we could agree that the curve would tend to become asymptotic. However, it is hardly to be expected that this study would discourage fixture cleaning when its purpose is to encourage good maintenance.

We hope the authors expand these tests, for the greatest need of the lighting industry for many years has been data of the sort the authors have presented, plus charts, tables or curves from which the economic value of maintenance for

*Champion Lamp Works, Lynn, Massachusetts.

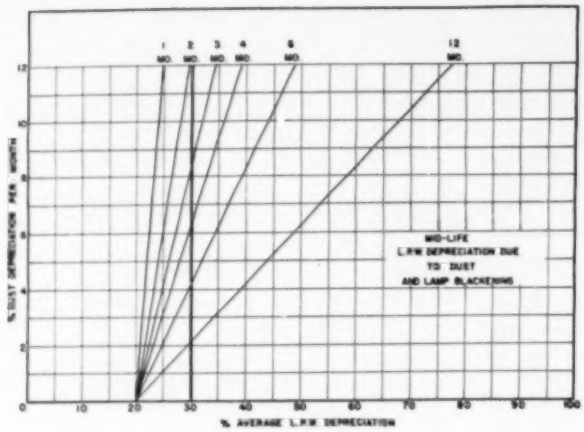


Figure 1 (discussion).

any condition encountered in actual use can be determined. Such material must, of necessity, be simple to use and it must provide for:

1. Any rate of light depreciation due to dust.
2. Frequency of cleaning periods.
3. Any labor rate.
4. Various power rates.
5. Various operating hours and total exposure hours.
6. Any wattage of the equipment involved.

While this paper presents an interesting accumulation of operating data, it does not yet provide such flexibility for application to other specific problems.

Fluorescent lighting maintenance charts which provide such flexibility are now available. One chart Figure 1 (discussion) shows the effect of cleaning at various times and at various monthly dust depreciation rates and also makes it possible to determine which rate will result in suitable pre-determined values of lighting maintenance. As a guide to maintaining lighting at 70 per cent of initial, the heavy vertical line at 30 per cent depreciation shows which monthly cleaning cycle will produce such results at various dust depreciation rates. This provides a quick reference chart which is easily applied. Another chart Figure 2 (discussion) shows the investment loss per year due to dust depreciation which can be saved by various cleaning cycles. A third chart Figure 3 (discussion) shows the power loss resulting from dust depreciation for various burning hours per year. By adding the values found from the latter two charts, it can quickly be seen how they compare with the cost of cleaning for any specific application and thereby the economics of cleaning can be determined.

Our charts are based on *average* dust depreciation rates per month. These are easily obtained by measuring the illumination before and after cleaning, then dividing the difference by the number of months between cleaning. While this assumes straight-line functions rather than asymptotic or exponential functions, it is believed to be much more practical than exponential curves, as well as

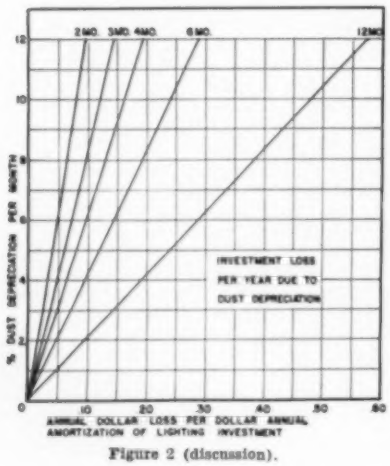


Figure 2 (discussion).

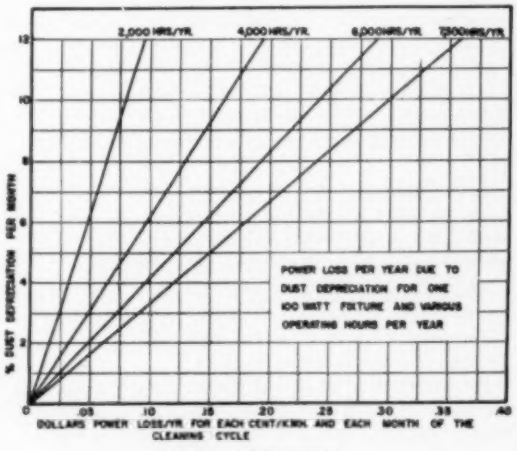

2,000 HRS/YR.
4,000 HRS/YR.
6,000 HRS/YR.
% DUST DEPRECIATION PER MONTH
POWER LOSS PER YEAR DUE TO
DUST DEPRECIATION FOR ONE
100 WATT FIXTURE AND VARIOUS
OPERATING HOURS PER YEAR
DOLLARS POWER LOSS/YR. FOR EACH CENT/K.W.H. AND EACH MONTH OF THE
CLEANING CYCLE

Figure 3 (discussion).

suitably accurate. This straight-line method eliminates the curving influence of the fluorescent lamp LPW curve by using fixed mean LPW values at mid-life. This is in line with the average depreciation methods considered by Gaetjens. This also seems to be in agreement with the "mean lamp output" values stated in the Paper "Fundamentals of Lighting Cost Analysis" presented at the I.E.S. Conference by Barr and Amick. We believe average dust depreciation rates are much more practical and acceptable to the consumer than exponential curves because with very few exceptions maintenance men just will not take the trouble to make all the readings necessary to the establishment of the exponential maintenance curves.

It is our belief that such material, combined with the case histories presented by the authors of this paper, provides maintenance facts, free of guesswork, which will be convincing enough to prove to any consumer the value of good planned maintenance.

GEORGE J. TAYLOR*: Papers on maintenance are always timely because they add to our past experiences of which we have little to show from a purely scientific point of view. Nevertheless, we know the importance of proper maintenance of a lighting system even though but few in industry do much about it. Floors are kept clean at quite frequent intervals per month at appreciable expenditures. Many plants allow five to ten minutes for cleaning machines at the end of a work day on company time. In most cases, it wouldn't take any longer to clean a lighting fixture. Yet, Egeler and VandenBoom would be pleased if a fixture or two per workman were washed only twice a year, which would take about one hour in time. Accumulated time of machine cleaning would probable average around 50 hours per year. So it takes about 50 times as much effort to keep a machine clean as it does a lighting fixture. Yet, a machine is just as efficient whether it is kept clean or not. A lighting fixture is only about 50 per cent efficient if not cleaned once or twice a year. That is an odd turn of events, is it not?

Chart 3 is interesting in many ways in showing the great benefits derived with a proper maintenance program. Based on the cost of $8.10 for 28 footcandles delivered, we find a cost of 28.9c per footcandle. For a 70c cleaning cost 12 footcandles are regained at a cost of 0.6c per footcandle. These "maintained" footcandles cost about one-fiftieth of the "fixed charge" footcandles. This proves that for return on investment the cheapest thing in lighting is maintenance. In spite of all this, no one has yet solved the big secret—why is it that very few take advantage of this magic of maintenance?

Table I presents some mighty interesting data. For one thing it substantiates the fact that lighting systems in industry operate at about a 50 per cent output. Millions of dollars are being wasted annually due to neglect of maintenance, in terms of light delivered to the job. Since level of illumination has a direct bearing on seeing, millions of dollars more are wasted due to loss in man-hours. If industry can afford these losses I'm afraid that our country cannot.

I note in Table I, in the four-month data presented, that lamp depreciation (by subtraction of percentages shown) varies from 10 to 22 per cent. Is there any accounting for this wide variation in a period of four months?

*Supervisory Lighting Engineer, Day-Brite Lighting, Inc., New York City.

The authors show in Figure 2 depreciation due to dirt alone in an engine assembly area. At the end of four months, the light output dropped to 74 per cent. Adding lamp depreciation to this light output it becomes 61 per cent. Mind you, this is only in four months. In industry we find other factors affecting light output such as voltage drops, lamp outages, lower reflectances, etc. Moreover, Figure 2 refers to an engine assembly room. Think of the many industrial areas that are far worse than an assembly area. Bearing this in mind, what value is usually substituted for M.F. in industrial lighting calculations? More often than not—0.7 when perhaps it should be closer to 0.5.

The authors have an interesting technique in testing and comparing different areas. As far as their tests are concerned, they only scratch the surface. For instance, you can compare only three industrial conditions in low bay areas. Some extremely useful data should eventually become available using the Egeler-VandenBoom procedure. This should be projected to all branches of industry, such as, printing, textile, leather, aircraft, can factories, etc. Then carry the tests on to the hundreds of departments of these industries containing inspection, assembly, cloth examination, tool rooms, machine shops, weaving, typesetting, etc. Added to all this are the many and varied conditions which prevail, such as, rough, medium and fine assembly; the weaving of cotton, silk, rayon and wool, and on and on as we think of all branches and departments of industry. Until we have such studies available how can we expect to assign proper values for M.F. in our lighting formula? Thank you, Egeler and VandenBoom, for a short paper on a big subject but nevertheless a good start. Keep up the good work.

C. E. EGELER and R. F. VANDENBOOM*: Mr. Vorlander's assumption is correct that the "comparison standard lamps" are those whose output characteristics are known.

The additional monthly data obtained since this paper was originally submitted show no significant departures from the trends of the first few months. Particularly in some of the high bay areas it appears as though the depreciation curves are rapidly approaching the asymptotic values (as shown in Rebuttal Figure 1).

We heartily agree with Mr. Vorlander that the use of straight line depreciation curves would greatly simplify the

*Authors.

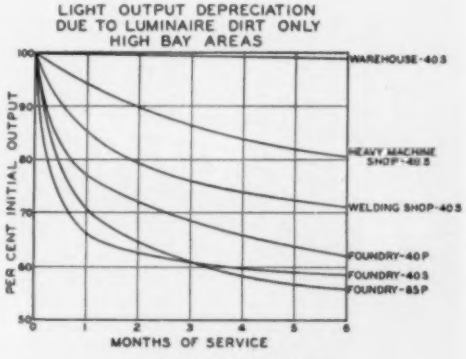


Figure 1 (rebuttal).

problem. Perhaps this method of analysis may be used with reasonable accuracy on some of the areas where the dirt conditions are not severe. In many cases, however, the test data obtained differ radically from straight line functions. Consequently, it appears that this straight line assumption does not give a correct basis for arriving at realistic maintenance factors, and cleaning intervals. Considering, for example, the luminaires installed in the foundry, if at the end of six months' dirt accumulation illumination readings are obtained before and after cleaning, according to the straight line assumption, the average loss of light due to luminaire dirt during the six months period is 21 per cent. In contrast, the integration of the test data obtained through the first six months indicates an average loss of 37 per cent. Unless the shape of the depreciation curve is known the true maintenance factor, as well as the most economical cleaning schedule, remains a matter of conjecture.

The difference in lamp depreciation values in the various test areas, as pointed out by Mr. Taylor, results from the different burning hours per month as shown in Table I.

We certainly agree with Mr. Taylor's feeling that these tests have "only scratched the surface." Until depreciation data are obtained covering the several variables which he outlines, we believe the maintenance factor will remain the most inaccurate element of lighting design. Perhaps with the cooperation and active interest of illuminating engineers throughout the country, using some standard maintenance testing procedures, the needed information might be made available in a relatively short period of time.

Luminous Ceiling Used in Hotel Restaurant

In the new Fayette Room of Pittsburgh's Sheraton Hotel the luminous ceiling is constructed of 48 corrugated white translucent acrylic sheets, each four by five feet in area, ⅛-inch thick with corrugations at 2½-inch intervals. The sheets are installed two feet below the 96-inch Slimline lamps, which are spaced on two-foot centers. Illumination at table level averages 33 footcandles. Photo courtesy Rohm & Haas Company.

Lighting a Wall Map

LIGHTING OBJECTIVE: To provide supplementary illumination for a wall-mounted service truck dispatch board.

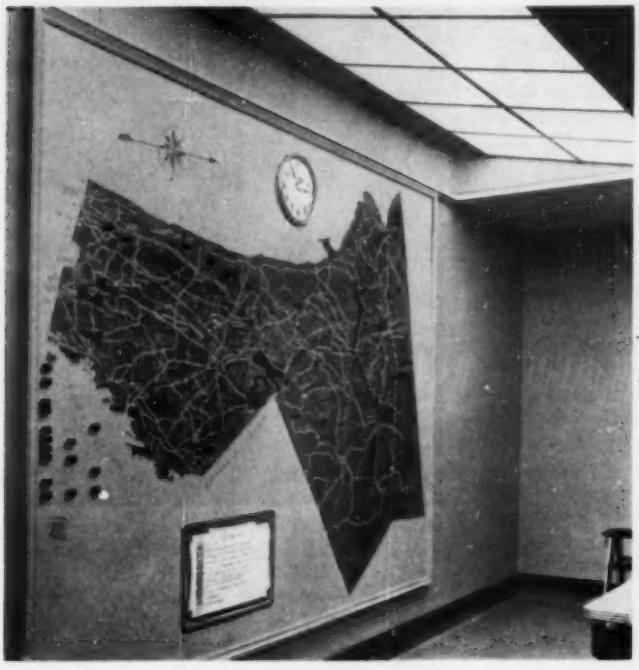


Figure 1.

Installation at
Consolidated Edison Company
of New York
9 South First Avenue
Mount Vernon, New York

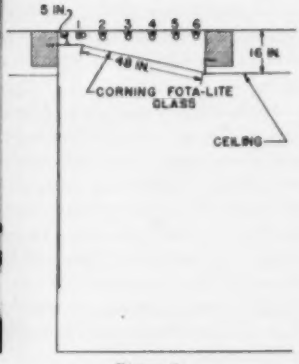


Figure 2.

General Information: Small magnetic plaques are used on this 10' 3" x 7' 11" aerial county map to show the locations of about 50 service vehicles equipped with radiotelephones and dispatched from this central office.

Installation: Figure 2 shows the details of the lighting installation. Eighteen 40-watt 4500K fluorescent lamps provide 40 footcandles on the vertical map surface. The lamps are shielded by Corning Fota-Lite louvered glass. Porcelain-enameled reflectors are used on rows 4, 5 and 6 to reflect the light generally toward the map. Resultant average brightnesses are as follows:

Green terrain area of map	7.7 ft-L
White surrounding area of map	33.5 ft-L
Lighting panel viewed at 45 degrees (not in line of sight of room occupants)	190 ft-L

Lighting designed by R. H. MacVean and E. L. Kosmider of Consolidated Edison's Westchester Division and installed by the Kent Manufacturing Company.

Lighting data submitted by Westchester Division, Consolidated Edison Company of New York, Inc. as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society
1860 Broadway, New York 23, N. Y.

A.I.A. File No. 31

The Cost of Seeing a Critical Industrial Task

By WILLARD ALLPHIN

THE physiological cost of seeing continues to offer an intriguing field for research in light and vision. One of the most promising methods for attempting to measure the "effort" in seeing is offered by the study of muscle action potentials from the forehead area. These potentials are the tiny voltages produced by muscles when doing work.

Travis and Kennedy have developed one apparatus[1] and Ryan and Cottrell, another,[2] for measuring these voltages and both groups have done preliminary work in relating them to illumination.[2,3] Indications were that ordinary reading is not a demanding enough task to supply reliable data with this technique, but that a task which is difficult visually might lead to more definite results.

Application of the method to some tasks in industry showed a correlation between tension level and illumination level only when the visual task was difficult.[4] There are many advantages to doing this type of work in a laboratory, but here a simulated industrial task must be used, and there is always the question of how valid the simulation is. Working in the factory involves many difficulties, but the great advantage of working with the actual task under actual conditions makes the attempt worth-while.

In the present project, an effort was made to find an industrial task of extreme difficulty, to measure the muscle potentials from the frontalis muscles and to record them automatically.

Task

In a factory manufacturing electronic equipment, female operators form a shaped bend in a "cat whisker" for a silicon diode detector. The wire, 0.002" in diameter, has previously been welded to a metal pin in the center of a ceramic cylinder. In the forming process, the long pin is placed in a jig and the combination is held in a fixture, Fig. 1, fastened to the work bench. The operator starts a bend by folding the wire over a knife edge with the closed end of a pair of tweezers and then brings down a lever which completes the bend, producing the shape shown in Fig. 2.

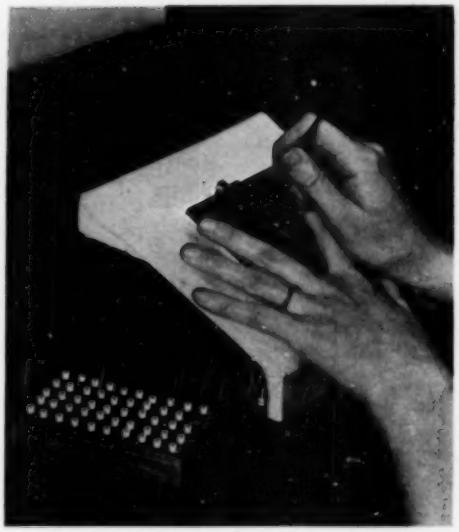


Figure 1. Forming "cat whiskers" for silicon diode detector.

The three points of critical seeing are: orienting the "cat whisker" in the jig; starting the bend with the tweezers; and inspecting the finished bend, Fig. 3, after removal of the jig from the fixture. The fixture is 3½ x 4 inches, mounted on a table 7¼ x 8 inches making an angle of 25° with the horizontal. It has been found that seeing is more comfortable when the small table is covered with white adhesive tape and this tape is changed when it becomes dirty. Holding the left hand over the fixture, as shown in Fig. 1, may be a further attempt to improve the brightness pattern. The bench has a top of brown presswood hardboard.

The "cat whisker" wire is too small for a measurement of reflectance, but this is unimportant since it is seen most easily in silhouette. Reflectances of other surfaces are:

Ceramic cylinder	Approximately 70%
Jig and fixture	7%-15%, depending upon amount of surface wear
Adhesive tape	61%
Bench top	9%

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Author: Sylvania Electric Products Inc., Ipswich, Mass.

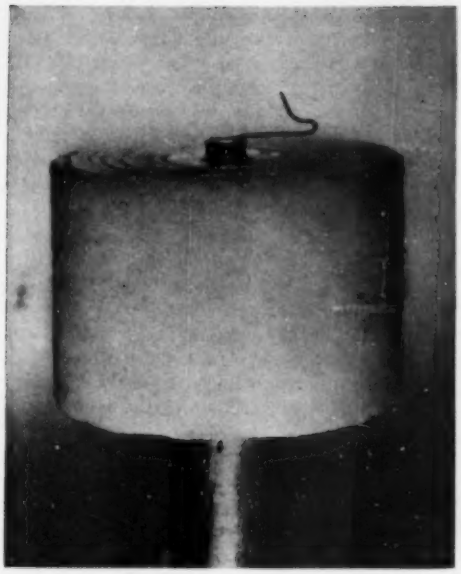


Figure 2. The task, enlarged 13 diameters.

Apparatus

Sponge type electrodes moistened with salt water are held on the forehead, just over the eyebrows, by means of a headband (Fig. 3). Three electrodes are used — one being a ground with the pickup balanced electrically on each side of the ground connection in order to reduce electrical interference. The output from the headband is fed through an electronic amplifier, integrator and rectifier to a photoelectric recording potentiometer. The latter produces a curve on a roll of chart paper traveling at a speed of 6 inches per minute.

A cathode ray oscillograph is connected ahead of the rectifier in order to keep a constant check on the wave pattern and show when a-c interference is being received. The normal lighting used in this operation is provided by a fluorescent fixture on an adjustable arm having two 4-watt daylight lamps, at a distance of approximately 4 inches from the work and providing approximately 140 footcandles at the "cat whisker." The luminaire used in the experimental work occupies approximately the same solid angle with reference to the work but consists of a bank of six 20-watt fluorescent lamps on grounded wiring strips and covered by a grounded wire mesh screen. This is 24 inches from the work.

Procedure

The apparatus was set up in a location away from the production area to minimize personal distractions, and parts were carried to the subject so that she could work uninterruptedly.

In the first phase of the work, the small portable luminaire was used and the footcandle level on the task was controlled by moving the luminaire closer to or further from the work. Measurements of tension level showed cyclical voltages with a pronounced peak each time the subject looked closely at the "cat whisker" in starting the bend with the tweezers. However, she tilts her head to the side at this point in order to better see the whisker, and it was found that the chart was actually indicating the proximity of her head to the luminaire.

This was because the electrodes were picking up

Figure 3. Task and instrumentation. Portable luminaire not in working position.

an electric field interference which was present even with the lamps switched off. This could be almost eliminated by grounding the luminaire, and further experiments might have been made with shielding the lamps, but in view of the highly sensitive nature of the pickup, it was felt better to use a larger luminaire further away and control the footcandle level by turning the lamps on and off. The lowest level was produced by one lamp with most of its surface masked.

Results

Due to the exigencies of factory production, the discomfort of wearing the headband for extended periods and the occasional bursts of electrical "noise" too strong to balance out, it was not found practicable to record any continuous runs of more than one hour in length. Runs were made at 1, 8, 35, 70, 100 and 160 footcandles in various sequences.

Other than an occasional sharp peak due to such things as talking, yawning, or wrinkling the brow, the output took a fairly smooth shape as shown in Figs. 4A and 4B. However, it was found that there was a measurable slope to the curve for any regular portion. With the subject relaxed, the curve slopes downward at approximately two units per minute. Under high footcandle levels, there is usually a downward slope and under low footcandle levels, an upward slope.

In a relaxed state, the Tufts studies[1] indicated that the tension level would slowly decline until the subject fell asleep, at which point, it would drop off sharply. Under plant conditions in this project, it was not feasible to have the subject fall asleep.

With an upward slope under low illumination, the general pattern is for the tension level to climb for several minutes, then behave irregularly for a few seconds, drop several units and start another slow rise as in Fig. 4A. It could be wished that these slopes were more pronounced, and an attempt will be made in the near future to increase the sensitivity of the apparatus, but the slopes are definite enough for measurement and have been confirmed by an independent observer working from the record tape without knowing the nature of the project.

Fig. 5 gives the results of several runs with five subjects. In order to have positive slopes for purposes of plotting against footcandles, two units per minute have been added to all measured slopes. Thus, in effect, everything has been tipped up in order to bring the relaxation line level. Putting it another way, the slopes shown in Fig. 5 are plotted relative to the slope for the relaxed condition. M. C. was inexperienced at the task which may account for her somewhat scattered results.

Although averages in this case have no precise mathematical significance, the averages of the

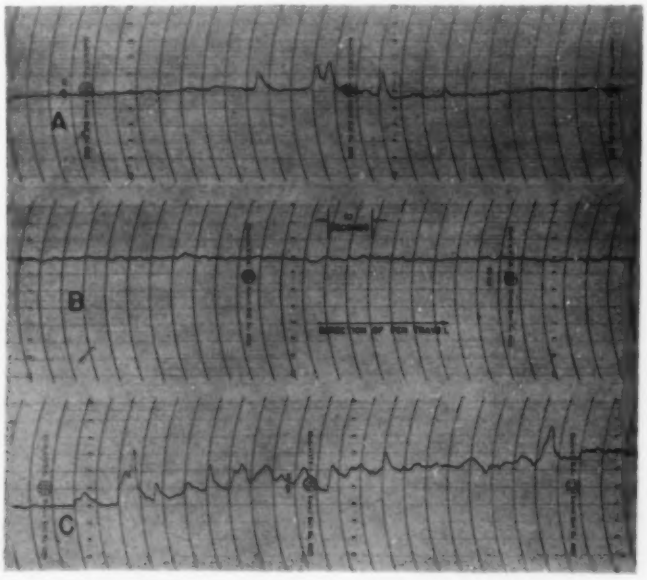


Figure 4. (a) Example of tension level at 1 footcandle. (b) Example of tension level at 100 footcandles. (c) Example of tension level with strong glare source in field of view.

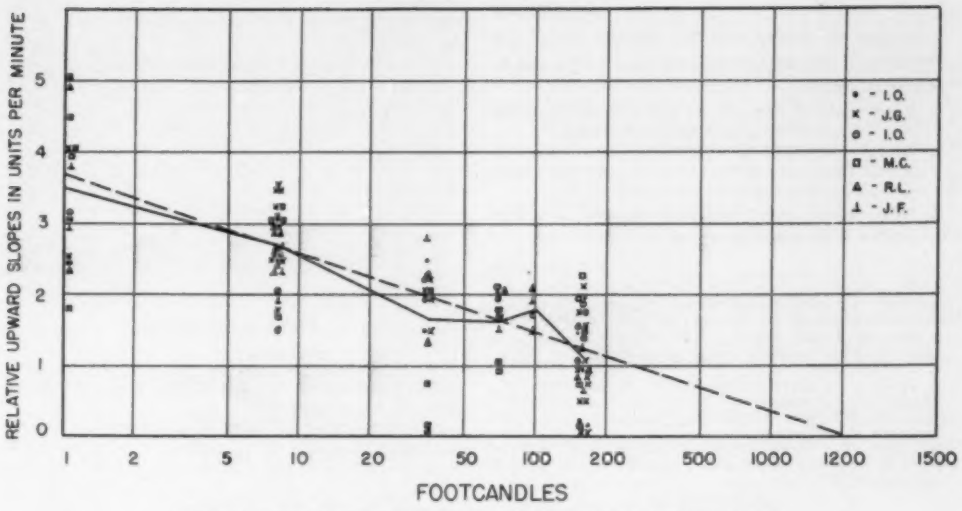


Figure 5. Slopes of tension level traces, relative to slope for relaxed state.

groups of readings have been plotted for the convenience of the reader in making his own estimate. The solid line connects the average points and the dashed line is a straight-line approximation of the solid one.

Introduction of a glare source at angle of 60° upward and slightly to the left of the line of sight produced patterns such as that in Fig. 4C. The glare source was a 60-watt white incandescent lamp.

At various times, when it did not interfere with the primary purpose of the project, measurements of production rate were made. In the early stages when the portable luminaire was producing interference, the count could be made from the peaks on the tape. In the later phases, when these peaks did not occur, the work was timed with a stop-watch. Average increase of production rate in going from 20 to 100 footcandles was 17 per cent.

Discussion

If the tension level shown in these results is significant, it represents neither the instant change in "effort" which might be expected in changing the visual difficulty of a task, nor the long range "fatigue" effect. It does seem to show the presence of what, in non-technical language, might be called "strain."

The desirability of doing some work with actual industrial tasks on the industrial scene makes it worth-while to struggle with the difficulties of avoiding electrical interference in a factory, but there remains much which can be done in the laboratory with simulated tasks where conditions can be better controlled and a completely shielded room can be used. The present work, however, adds further credence to the measurement of muscle action potentials as a criterion of the cost of seeing and suggests that for this particular task, benefits would increase under illumination levels up to the order of 1200 footcandles.

While the glare exposure used in this project was severe, the response was so immediate and pronounced that it appears promising for further work with less bright sources and at various angular positions under controlled, laboratory conditions.

The extreme sensitivity of the apparatus to ungrounded electrical elements in the surround and the absence of cyclical peaks when interference is removed, casts doubt upon the curve shown for reading the dates of pennies in the discussion of a previous paper.[4] It also throws doubt upon the peaks shown for the soldering operation described in the same paper, but still implies significance to the generally higher tension level under low illumination.

As a side-light, the extreme sensitivity to electrical interference might provide a useful tool to industrial engineers in studying some types of factory operation. Electrically charged plates mounted at appropriate spots could be arranged to provide a very sensitive reflection of bodily movements and record them on a tape.

Conclusions

Subject to confirmation by further work with similar and with other tasks, the conclusions can be stated as follows:

1. Measurement of muscle action potentials shows promise as a criterion of the physiological cost of seeing.
2. Field measurements can be made on a task such as described above, but not for periods of time long enough to establish long-range fatigue effects.
3. Extrapolation from these data suggests 1,200 foot-candles as the specification for lighting this task.

Bibliography

1. Travis, R. C., and Kennedy, J. L.: "Prediction and Control of Alertness," *Journal of Comparative and Physiological Psychology*, Vol. 42, p. 45 (1949).
2. Ryan, T. S., and Cottrell, C. L.: "Muscular Tension as an Index of Effort," *American Journal of Psychology*, Vol. LXIII, p. 317 (July 1950).
3. Travis, R. C., Kennedy, J. L., Mead, L. D., and Allphin, W.: "Muscle Action Potentials as a Measure of Visual Performance Cost," ILLUMINATING ENGINEERING, Vol. XLVI, p. 182 (April 1951).
4. Allphin, W.: "Muscle Action Potentials as Related to Visual Tasks in Industry," ILLUMINATING ENGINEERING, Vol. XLVI, p. 188 (April 1951).

DISCUSSION

C. E. EGELER*: The author is to be commended for his further exploratory investigations using an actual industrial task in measurements designed to indicate the physiological effect of change in illumination level on the worker. These new results and the methods of analysis indicate that the muscle action potential method may provide us with additional definitive information for establishing the ideal level of illumination for specific tasks.

There is need for a closer tie-in of specific tasks to laboratory studies on the effort and fatigue, and other effects of various lighting levels and qualities, for production workers. This method ultimately may do this. The task chosen is one of many which might be selected as representative of many which involve critical seeing. As time permits, others should be included in additional studies so that a mass of data can be accumulated in order that more significant and far-reaching conclusions can be drawn; they are needed to provide added basic evidence why better lighting not only increases production but does it at lower cost in human effort, with accompanying benefits which reduce errors and improve work quality, which are also important factors in the net output per worker.

A promising technique such as this should be thoroughly checked in the laboratory where more complete control can be exercised over the environmental and experimental conditions. It would be interesting to determine how well it can be applied to other types of tasks, especially those involving less physical activity on the part of the worker. By a systematic study it may be possible to isolate the various types of electrical responses obtained and thereby to make a more complete analysis of the relationship between work and effort.

DOMINA ESERLH SPENCER**: Mr. Allphin should be congratulated for making a very interesting and important contribution to our understanding of the "cost of seeing." His results show a measurable improvement from using large quantities of light for seeing a very difficult task.

*Lamp Division, General Electric Co., Nela Park, Cleveland, Ohio.
**University of Connecticut, Storrs, Conn.

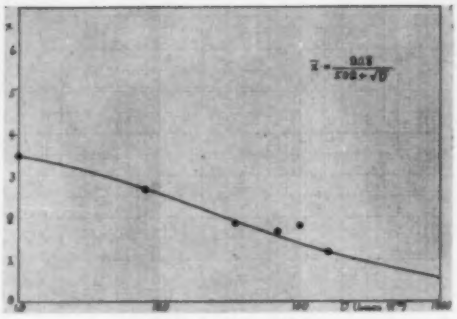


Figure 1 (discussion).

They are in agreement with our daily experience and with what we instinctively feel to be correct. I hope that he will continue his excellent work.

We realize today that more important than the quantity of light is the quality of the lighting. Thus, it would seem that the Allphin technique might very well be applied to obtaining data on the effect of non-uniformity in the field of view. Certainly this is a highly important subject to all of us and it is one where the ordinary methods of attack have not been very effective. It would be interesting to investigate by the Allphin method the effect of changing the reflectance of the desk top, or to find how the cost of seeing varies when we change from a uniform visual surround to one with a 3:1 or 10:1 ratio. This might give some further justification of the 3:1 ratio recommended by the Illuminating Engineering Society. Direct and reflected glare might also be investigated by this method.

There is, however, one point on which I wish to offer constructive criticism. It is on the method of evaluating the experimental results. In the past it seems to have been customary for illuminating engineers always to represent their data by straight lines even when extrapolation leads to ludicrous results. In the present case, for instance, we know that the curve cannot cross the axis so a true representation of the data should approach an asymptote of zero. In the accompanying figure is shown a simple curve

$$\bar{x} = \frac{20.8}{5.02 + \sqrt{D}}.$$

The averages of all of Allphin's experimental data are indicated by black dots. The only experimental point which is not very close to the curve is that for 100 lumen ft^{-2}. This point represents an average of only four observations and is probably not significant.

The point I wish to make is that the illuminating engineer should resist the temptation to represent psychophysiological data by straight lines. Rarely, if ever, does the eye behave in such a simple manner. Thus, we should try to represent visual data by a curve which will not give absurd predictions at large values of brightness.

E. SIMONSON*: Mr. Allphin's paper is most interesting and encouraging for the further development of visual research for two reasons: the studies were performed in a "miniature job situation," and a general physiological criterion (muscle action currents) was used instead of the conventional visual acuity measurements. The meth-

*University of Minnesota, Minneapolis, Minn.

od could be improved, however, by taking the leads from several instead of only one muscle group, and by using a battery of tests instead of a single method.

While we wish to congratulate the author on his approach and design of the experiments, we disagree with his evaluation, interpretation and conclusions. A continuous relaxation trend can be taken as baseline for evaluation only when it is linear throughout the period of observation. This is quite unlikely, and more information on this point would be desirable. The difference in the slope of the curves between 1 and 100 ft-c, as shown in Fig. 4, is very slight and subject to a considerable error in measurement. No information is given about repeat variability.

It is not surprising, therefore, that the scatter of the experiments (Fig. 5) is enormous. While there seems to be a trend from 1 to 35 footcandles, it can be safely predicted that there is no statistically significant difference between the means at 35, 70, 100 and 160 footcandles. Therefore, the results show a beneficial effect of illumination only up to 35 footcandles. The extrapolation beyond 160 footcandles is not warranted, and the conclusion that improvement will result up to 1200 footcandles is grossly misleading. Due to the enormous scatter, it is also futile to argue whether a straight line or Dr. Spencer's equation will fit better. Within the wide limits of the scatter, no statistically significant difference between a straight line, Dr. Spencer's curve, or other curves could be established.

WILLARD ALLPHIN*: In the verbal presentation of this paper at Washington I said,

> "In attempting to establish a criterion for the cost of seeing, or in attempting to apply it when established, one must decide, for any particular project, whether to work in the laboratory or in the field. The laboratory offers the advantage that extraneous electrical factors can be eliminated by working in a shielded room, and that extraneous human influences can be reduced by the laboratory environment and the selection of suitable subjects. However, in the laboratory a simulated task must be used and this always brings with it the horrid question of whether or not it is a valid analogy to the actual task.
>
> "In the field we do have the difficulty of working under distracting conditions both physically and psychologically, but the task itself can be the actual one under study, which offers great advantage. Both types of approach are necessary and should be correlated with each other insofar as possible. It is the factory situation, in spite of its attendant difficulties, which most appeals to me and which was used for this study."

This, I believe, answers the question raised in Mr. Egeler's communicated discussion.

At the same time I explained that the original paper had been submitted with only the data points given in Fig. 5. It was felt that there was a downward trend, but that it might be better to leave it to each reader to draw in his own curve. However, the Papers Committee requested that a average curve be shown, and this was done.

The extrapolation of the curve is, of course, only speculative and I do not agree with Dr. Spencer that it should necessarily approach zero as an asymptote. It is at least as reasonable to suppose that it may turn upward again at some footcandle level where the task becomes uncomfortably bright.

Dr. Spencer's suggestion that brightness ratios should be varied is a good one, but I believe that more work is needed with this method on footcandles before we proceed to brightness levels.

Dr. Simonson suggests that voltages should have been picked up from several muscle groups instead of just from the frontalis muscles. The Tufts psychologists are familiar with the work at Cornell where several pick-up points are used, but they still prefer the frontalis. Certainly this is more convenient for field work.

As to the statistical reliability of the results, since Dr. Spencer is, in effect, saying that the results are better than claimed by the author, and Dr. Simonson is saying that they are worse, the author would prefer to remain on the sidelines until the next project provides more data.

*Author.

LIGHTED NICHES provide indirect-type background illumination in a dining room. One single-lamp fluorescent luminaire is mounted against the wall eight inches above the top edge of each niche and is shielded by a frosted glass panel which lifts up for lamp changing. The four sections of the longer wall contain 15-watt fluorescent lamps. Photo courtesy Sylvania Electric Products, Inc.

Doorways to Christmas

Christmas is the season of hospitality, and many home makers realize that their front doors can help to spread gaiety and give cheer. To achieve this the Christmas decorations are dramatically lighted—for they must be lighted to be seen.

This simple but effective Christmas decoration was made by the lady of the house, herself. Santa's face is of papier mache, with pine needles dipped in silver paint forming eyebrows and whiskers. The head is mounted on a red circle. White cut-out letters form the greeting. The entire decoration is illuminated by a projector floodlamp mounted at the right upper part of the door.

The white doorway (right) is outlined with Christmas tree roping and peeping through the greens are a string of lights with star shapes behind the bulbs. Behind the storm door, a big Christmas card made of green shiny paper is attached to the front door, with white cut-out letters for the greeting. A big red bow and pine cones top the card. A concealed projector flood lights the whole display.

A "Christmas card" house (below), outlined in lights has in addition to strings and laurel roping floodlighting from several locations on the lawn.

The home maker created this doorway decoration (below right) herself, at small expense. Pine roping and outdoor colored strings outline the door. Black and white oilcloth and a Santa Claus face create the illusion of Santa standing there. The doorway is spotlighted by a projector flood in a bracket on the lower step at right.

Photos and data supplied by Myrtle Fahebender, Director of Residential Lighting, Westinghouse Lamp Division, Bloomfield, New Jersey.

Transportation Lighting

Including Buses, Street Cars, Rapid Transit and Railway Trains

Report prepared by the I.E.S. Committee on Interior Lighting for Public Conveyances*

FOREWORD

This report is the result of two years' work of a committee comprising representatives from lamp, lighting equipment and public conveyance manufacturers, city boards of transportation and the American Transit Association.

I.E.S. Committee on Interior Lighting for Public Conveyances

E. W. Beggs, *Chairman*

A. L. Arenberg	E. Hatch
W. N. Bodkin	J. L. Heine
C. I. Brady, Jr.	H. H. Helmbright
J. C. de la Rosa	J. L. Swarner
E. B. Hallman	W. C. Wheeler

THE GENERAL principles established for good interior and exterior lighting apply also in the transportation field. However, limited supply of electric power and the special basic characteristics of this power in buses and railway cars often make it a more difficult and expensive problem to provide interior illumination of recommended quantity and quality. Also, the tremendous length of highways and railways, the fact that they are used intermittently, and their exposure to a wide variety of weather conditions are important factors which complicate the lighting problem.

The following requirements are of special importance in the transportation field. They apply to the lighting of practically all types of vehicles but are, of course, more essential in some than in others.

1. Adequate levels of illumination on the reading plane. Where the reading matter tends to vibrate, a relatively higher level of illumination is needed than for a fixed seeing task.
2. Adequate illumination at special locations to permit safe entrance, exit and movement of passengers.
3. Lighting for fare and ticket collection.
4. Adequate vision of operator, particularly freedom from reflections or glare spots in his field of vision.
5. Minimum glare and brightness ratios for passengers' eye comfort.
6. Cheerful and attractive appearance of the vehicle inside and also as seen from without.

Most vehicles are long and narrow, have low ceilings and large window areas. Also, the desires of the passengers and the loading of the conveyance vary. These factors make the lighting problems difficult. On the other hand, the position of the occupants and of the operator is generally known and fixed so that good lighting results are obtainable through a careful study of all phases of the problem.

In the transportation field direct current power supplies are predominant, a wide variety of voltages are involved, and power is often limited. For these reasons, one of the principal problems is to adapt lamps and lighting equipment to the power available and particularly to provide suitable power for fluorescent lighting, which is discussed later under "Electric Systems for Operating Fluorescent Lamps in the Transportation Field."

Motor Coach Lighting

There are two general types of motor coaches — the city and the inter-city motor coach. The lighting requirements are different for each.

City Motor Coach.—General interior lighting is required continuously during night time operation of a city motor coach for speedy loading and unloading, to attract passengers, to illuminate advertising cards and for casual reading. The level should range from 15 to 30 footcandles throughout the passenger areas of the coach.

The level of illumination should be measured at a point 33 inches above the floor either on the horizontal or on a 45-degree plane, depending upon the design of the coach.

The lighting system generally consists of two longitudinal rows of luminaires mounted on the ceiling. Each row is located approximately over the center line of the seats on either side of the coach as illustrated in Fig. 1. The location, number and brightness of luminaires should be chosen so as to minimize direct glare, reflected glare and shadows.

*Approved by the I.E.S. Council, June 1951.

Figure 1. City bus. Fluorescent luminaires mounted end-to-end over the passenger seats provide diffuse semi-direct illumination. The 42-inch T-6 instant start lamps used are operated from an engine-driven constant-voltage variable-frequency generator. Incandescent dome lights each containing one 21-candlepower 12-16 volt S-8 (No. 1141) lamp provide standby service when engine is not running.

Figure 2. Inter-city bus. Individually controlled beam-type lights containing 21-candlepower 12-16 volt S-8 (No. 1141) incandescent filament lamps are mounted in the base of the baggage rack to provide each passenger with a reading light. An indirect lighting system comprising a cove with incandescent lamps is built into the edge of the baggage rack for general interior illumination.

Ceilings and upper walls should be of high reflectance (in the order of 60 to 85 per cent) to increase lighting efficiencies; and lower walls, upholstery and floors should be of relatively light colors (15 to 30 per cent) to minimize brightness ratios in the passengers' field of view.

Provision should be made for adequate illumination of *step wells* and of the ground area for at least 4 feet from the steps. The light sources should be designed, located and arranged so as to minimize the casting of shadows, prevent glare in the eyes of both passengers and driver, maintain a uniform level of illumination and remain permanently in adjustment.

Provision should be made for the proper illumination of the *fare box* or fare collection facilities. This may be done with a ceiling mounted unit or a local light.

Figure 3. Street car. A continuous row of 48-inch fluorescent lamps along each side plus one lamp across the end provides diffuse direct-indirect illumination. Lamps are operated on a special circuit utilizing the available 600-volt d-c power.

Figure 4. Rapid transit car. Direct general lighting is furnished by two continuous rows of luminaires using 72-inch T-8 instant start fluorescent lamps operating on 60-cycle a-c power from a motor alternator. A 42-inch T-6 lamp is mounted transversely at each end of the car to provide additional light in the vestibule. Light-colored walls, floors, upholstery minimize brightness differences.

Figure 5. Railway coach. Units containing 50-watt 32-volt incandescent lamps mounted on the ceiling directly over the aisle provide semi-direct general interior illumination. Incandescent 40-watt 2-8½ inside-frosted showcase type lamps are mounted under the baggage racks above each double seat to provide adequate light for reading and to supplement the general illumination throughout the car. The lamps are shielded by dense enamel on the sidewalls of the glass, and a lens controls the light to produce higher intensities on reading plane.

Figure 6. Railway passenger coach. Two rows of fluorescent lamps mounted on each side of the car above and below the baggage racks provide general indirect car illumination and direct lighting for reading. The upward component reduces the brightness ratios in the passenger's field of vision. Each row consists of ten 40-watt T-12 and two 30-watt T-8 lamps operated from 220-volt a-c provided by a generator driven by the car battery. Incandescent night lights located in the seat pedestals provide controlled illumination in the aisle.

Destination signs are ordinarily provided both on the front and the side of the vehicle. The signs should be legible at a distance both day and night. The usual sign is of the single or multiple cloth roller curtain type, with white letters on a black background.

Inter-City Motor Coach.—General interior lighting is recommended to illuminate the entire coach to a level of 15 to 30 footcandles. This system is used at important stops to give the bus an attractive interior appearance and to speed up loading and unloading. It is generally turned off when on the road to allow passengers to rest or sleep and to allow the driver's eyes to adjust to the brightness of the road.

For those persons who want to read while others sleep, individually controlled beam type reading lights such as those shown in Fig. 2 are usually provided. At minor stops, a special aisle lighting system of moderate intensity is turned on to facilitate passenger movement without disturbing those who are asleep. A low intensity night light system, on a separate switch, is often desirable so that the driver may clearly see throughout the entire bus.

Special lights are often provided for the baggage compartment.

For the lighting of step wells, fare boxes or fare collection facilities and destination signs, see the recommendations given above for city motor coaches.

Trolley Coach and Street Car Lighting

The general requirements are the same as for city motor coaches, but since the amount of power available is not limited it is practical to attain higher levels of lighting. The recommended current practice is 20 to 30 footcandles. See Fig. 3.

Rapid Transit Car Lighting

Rapid transit cars are those generally operated in trains in subways or on elevated structures, or both. The general requirements for the lighting are similar to those of city motor coaches and street cars but the power available for lighting is relatively unlimited and more comfortable and effective light is ordinarily provided for reading.

The lighting system generally consists of two or three longitudinal rows of luminaires. See Fig. 4. The location, number and brightness characteristics of the luminaires should be such as to minimize direct glare, reflected glare and shadows.

Ceilings and upper walls should be of high reflectance (in the order of 60 to 85 per cent)to increase lighting efficiencies; and lower walls, upholstery and floors should be relatively light colors (15 to 30 per cent) to minimize brightness ratios in the passengers' field of view.

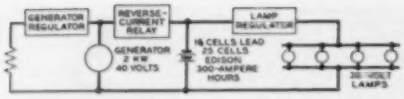


Figure 7. Typical railway car electrical circuit showing the axle-generator for use with 30-volt incandescent filament lamps.

Railway Passenger Car Lighting

A railway car is basically similar to a rapid transit car and so the same general requirements apply to both. Rail cars are generally designed for long trips, however, and the illumination should be planned for more passenger comfort and freedom of movement.

In the standard railway passenger car most of the lighting is ordinarily provided by overhead luminaires. Figs. 5 and 6 show typical modern installations. If the luminaires are located in the center of the aisle, additional units are generally located under the baggage racks for comfortable reading by the passengers. Adequate illumination is required for safety and convenience of the passengers on the aisles and the steps, with sufficient light provided on the ground or the loading platform out to a distance of at least 4 feet.

In railway coaches where passengers may desire to read while others sleep, individually controlled reading lights should be provided. Also, a special aisle lighting system of moderate intensity is usually installed to permit safe movement with a minimum of general illumination. A night light system is often provided to illuminate the entire interior of the car to a low level without disturbing sleeping passengers.

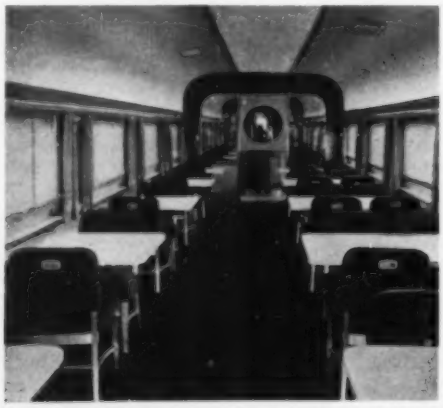


Figure 8. Railway dining car. Continuous rows of 40-watt T-12 fluorescent lamps behind valances above the windows provide both direct and indirect lighting.

The ceilings and upper walls should be of light colors with a reflectance of from 60 to 85 per cent to increase lighting efficiency; lower walls, upholstery and floors should be of light colors to minimize brightness ratios in the passengers' field of view. Glare, especially in the eyes of seated passengers, should be reduced to provide eye comfort.

Special purpose cars such as dining cars (Fig. 8), lounge cars (Fig. 9) and sleeping cars (Fig. 10) present individual lighting problems depending on their particular design and use. In all, however, there should be adequate light for the safety, convenience and comfort of the passengers in their normal activities.

The following table shows the current recommended lighting levels for various activities in railway passenger cars.

Reading and Writing*	
Casual	20 footcandles
Prolonged	40 footcandles
Dining	15 footcandles
Social Areas	15 footcandles
Tavern	10 footcandles
Steps and Vestibules	10 footcandles
Mirror (on face)	30 footcandles

*The 40-footcandle level of illumination is preferred because of vibration of the seeing task.

Lamps and Electric Power Systems For Transportation Lighting

Lamps.—In general, the majority of conveyances now in operation are lighted by incandescent filament lamps, but in the postwar years, there has been a decided trend toward fluorescent lighting in the newer units. The high efficiency, long tubular shape and low brightness of the fluorescent lamp make it well suited to vehicular lighting. However, few public conveyances have the normal 60-cycle 118-volt alternating current for which most fluorescent lamps and accessories are designed; consequently, special electrical system have been devised to facilitate the use of fluorescent lamps in this field.

The efficiency of lamp regulators used with either incandescent or fluorescent lamps on direct current is approximately 80 per cent; motor alternators used to provide a-c average 60 per cent. The overall efficiencies of transportation lighting systems are usually compared on the basis of battery watts required for equal lumens (or lumens per battery watt. For example, a 40-watt T-12 4500K* preheat start fluorescent lamp and ballast** require

*Also called "cool white."

**Ballast power consumption and lamp lumen outputs may be obtained from the manufacturers or from Section 8 of the *IES Lighting Handbook, Second Edition.*

Figure 9. Railway parlor car. A central continuous double row of shielded 15-watt T-8 fluorescent lamps operated on 110-volt a-c provides semi-indirect general illumination. Reading light is supplied by 75-watt incandescent filament lamps mounted above diffusing glass in the baggage rack over each chair seat.

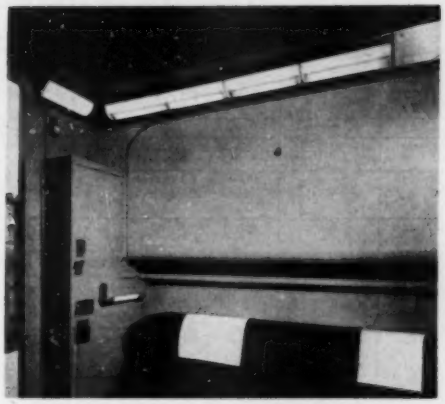


Figure 10. Railway bedroom. Five 14-watt T-8 fluorescent lamps in direct cornice-mounted units provide general illumination. This type unit can be used in roomettes also. The small fluorescent lamp mounted on the wardrobe supplies supplementary lighting for reading in a seated position and serves as a bed lamp for the lower berth.

48.4 watts (55 watts of ran instant start lamp); since the motor-alternator used to provide 118-volt a-c power has an efficiency of 60 per cent, 80.7 watts per lamp (91.7 for instant start lamps) are required at the battery; with a lamp output of 2250 lumens** this system gives 27.9 lumens per battery watt (24.5 for instant start). A 14-watt T-12 4500K* lamp operating on 60-volt direct current with ballast and regulator requires 27.8 battery watts and provides 17.1 lumens per battery watt.

Electric Systems for Operating Fluorescent Lamps in the Transportation Field.—Fluorescent lamps were primarily developed for a-c operation and are generally more efficient and satisfactory when operated on a-c, but a d-c power supply for lighting has been the accepted standard in the transportation field until recent years. Certain sizes of fluorescent lamps may be operated directly on the d-c available on the vehicle or a-c may be generated from the available d-c supply by means of various types of conversion units.

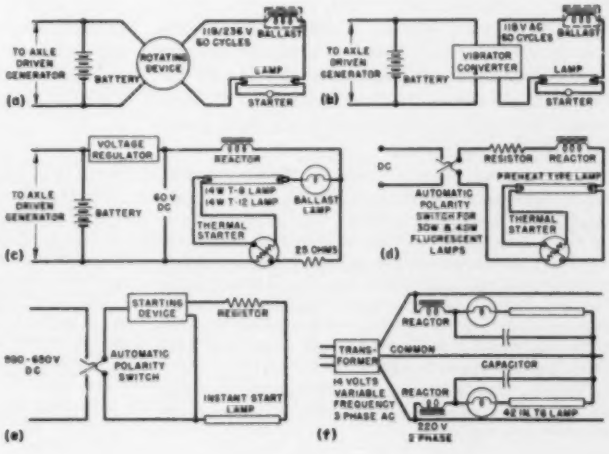


Figure 11. Typical circuits for operating fluorescent lamps in the transportation field: (a) and (b) Circuits for converting available d-c to 60-cycle a-c. (c) Circuit for operating 14-watt fluorescent lamp from 60-volt a-c power supply. (d) Circuit for operating preheat fluorescent lamps from d-c power supply (110 volts or higher). (e) Circuit for operating instant start fluorescent lamps from 600-volt d-c power supply. (f) Circuit for operating 42-inch T-6 Slimline fluorescent lamps on variable-frequency constant voltage from engine-driven generator.

TABLE I.—Vehicular Power Supplies Suitable for Fluorescent Lamps.

Voltage	Frequency	Locations Used	Circuit Diagram Fig. 11	Comments
12-16 24-28	d-c	buses, motor coaches, small boats	a, b	Must be converted to a-c. Cith 118-, 208- or 236-volt 60-cycle a-c standard lamps and auxiliaries may be used. Other voltages and
30-34	d-c	steam railway cars	a, b	frequencies require special auxiliaries.
60-64	d-c	steam, diesel and electric railway cars	c	14-w 12" T-8 and 15" T-12 d-c lamps with special d-c auxiliaries may be used. All other lamps require conversion to a-c.
100-125	d-c	ships and some recently-built railway cars	d	14-w 12" T-8, 14-w 15" T-12, 15-w 18" T-8 or T-12, 20-w 24" T-12, and 25-w 33" T-12 lamps may be used with d-c auxiliaries. Other lamps require higher d-c voltages, or conversion to a-c.
220-250	d-c	ships	d	Preheat bipin base lamps using special d-c auxiliaries. Other lamps require conversion to a-c.
575-650	d-c	street cars, trolley coaches, rapid transit cars, & some electric railways	d, e	All sizes of preheat and instant start lamps up to and including 72" long with special d-c auxiliaries. Frequent power interruptions ande wide variations in voltage and temperature may require special hot or cold cathode lamps for satisfactory performances.
14	80 to 500 cycles	new motor coaches	f	A constant voltage variable frequency alternator is driven at varying speeds by vehicle engine. Transformers provide open circuit voltage required and special circuits and auxiliaries operate specific instant start and slimline fluorescent lamps at proper current values.
110-125	25 cycles	electric railway cars		Special 25-cycle ballasts available but stroboscopic effect is objectionable. Conversion to 60-cycle a-c recommended.
220-250	60 cycles	electric railway cars		All types and sizes of lamps if suitable auxiliaries are used.

With d-c operation of fluorescent lamps, a resistance type ballast is used to control the current. Ballast loss should be included when determining the total power required for the lighting. Also, the direction of the current flow through the lamp should be periodically reversed to prevent the reduction in light output at the positive end of the lamp caused by the gradual drift of the mercury to the negative end. The useful lamp life on d-c burning is reduced to approximately 80 per cent of that on a-c burning. Special provisions are needed to assure dependable lamp starting at low line voltage and at lower ranges of ambient temperature.

If a power conversion is necessary, it may be advisable to convert to 60-cycle a-c which permits the use of standard lamps and auxiliaries. However, special combinations of lamps and circuits such as, for example, 400-cycle a-c may be used for such as for example 400 cycle a-c may be used for specific applications. The power losses in the conversion unit should be included in the total power required for the lighting.

There are two common methods of conversion in use to produce a-c from the basic d-c power source available.

1. Rotary Machines — Such devices as rotary converters, motor alternators, booster inverters, etc., are being used on d-c voltages to generate various a-c output voltages. Gasoline-electric or diesel electric equipment is being made available for mounting beneath a car and for a "head-end" a-c power system.

2. Vibrator and other interrupting devices which produce a pulsating d-c energy use a transformer to provide the required a-c output voltages.

The ballasts and all auxiliary equipment should be properly designed for good lamp performance. They should not overheat and should provide ample open circuit voltage, good wave form and proper operating current for the lamps. If ordinary commercial ballasts and starters are used, the frequency and voltage of the a-c power should be controlled and the operating current of the preheat type lamps should be held within ±15 per cent of the rated values in order to obtain satisfactory lamp life. Special combinations of lamps and auxiliaries may be used, however, to meet certain conditions where wide ranges of voltage or frequency, or both, are encountered.

The best electrical system and the preferred types of fluorescent lamps to be used are determined largely by the type of electric power available in the vehicle. Table I lists each important type of power now encountered in the transportation field and the fluorescent lamps which may be operated on it.

Bibliography

1. Helmbright, H. H., and Lee, F. B.: "Modern Lighting for Modern Transportation," *Trans. Illum. Eng. Soc.*, Vol. XXXII (January 1937).

2. *Urban Motor Coach Design Objectives*, American Transit Association, New York, 1947 (circulation restricted).

3. "Lighting a Subway Car," (I.E.S. Lighting Data Sheet No. 28-1). ILLUMINATING ENGINEERING, Vol. XLIV (January 1949).

4. Beggs, E. W., and Graybrook, H. W.: "Development of A-C Fluorescent Lighting for New York City Subway Cars," ILLUMINATING ENGINEERING, Vol. XLV (October 1950).

5. Brady, C. I., Slauer, R. G., and Wylie, R. R.: "Fluorescent Lamps for High Voltage Direct Current Operation," ILLUMINATING ENGINEERING, Vol. XLIII (January 1948).

6. "Uses of Electric Power," *Westinghouse Engineer* (January 1948).

7. Campbell, J.: "High Frequency Operation of Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. XLIII (February 1948).

T E L E C A S T
LIGHTING NEWS OF CURRENT INTEREST

National Technical Conference

August 27-30, 1951 — Washington, D. C.

About 765 delegates and guests attending the 1951 I.E.S. National Technical Conference can all testify that Washington, D. C. in August is a delightful place to be. The temperature was pleasant, the relative humidity low—any fears to the contrary were absolutely unfounded.

The real success of the Conference had nothing to do with the climate, however. It was the result of planning, an unusually full program of technical sessions and social activities, and wonderful hospitality of all members of the host (Capital) section. The Shoreham Hotel, headquarters for the Conference, had a happy combination of facilities for either recreation or serious business, which contributed no little to the excellence of this year's Conference.

Technical Program

Forty-five technical papers presented in fifteen sessions, comprised the technical program. Properly speaking, however, the many technical committee meetings held throughout the Conference should also be considered a part of the technical program. No less than 32 technical committee meetings were held during the four days, many of them being scheduled for breakfast, luncheon, dinner and evening, so as not to conflict with the Papers Sessions. The presence in one place, at one time, of so many members afforded a chance not to be missed to hold committee meetings with full personnel.

An especially interesting meeting was held Wednesday evening by the Street and Highway Lighting Committee when 25 members toured Washington in six private cars to inspect the street lighting of the city.

Another notable meeting, not listed as a Technical Papers Session, was the meeting on Military and Civil Defense Lighting held Tuesday evening in the main ballroom. Attracting a large attendance, this meeting was an especially timely and valuable symposium on Lighting for Defense. Many military and government people directly concerned with the subject participated, and to the extent allowed by security, discussed problems relating to defense and lighting. A detailed list of speakers at this meeting is given at the end of this report.

Progress Report

A detailed account of this ever-popular report on developments in the lighting field may not be necessary in print. Even before Alston Rodgers, Chairman of the Progress Committee, arrived in Washington, he had been requested to present his report at a number of section meetings and regional conferences. Most of the Society members therefore, may have an opportunity before the year is out to see it for themselves.

They have a treat in store. Valuable interesting lighting information is dramatized in its presentation, in Mr. Rodgers' inimitable manner, to form a show well worth seeing. Those section meetings featuring it should be packed. Certainly this session at Washington was. Late comers could not even find a seat, an many hundreds considered that Wednesday evening a highlight of the Conference.

Opening Session

The Washington Conference was officially opened at 9:30 a.m. on Monday, August 27, with R. F. Hartenstein officiating as Chairman of the opening session. An invocation by Canon Luther D. Miller, Chaplain (Major General U. S. Army retired), Canon of the Washington Cathedral, opened the proceedings.

The Address of Welcome was given by Mr. R. Roy Dunn, President of the Potomac Electric Power Company.

Mr. A. H. Manwaring, General Secretary, presented his report on the Society's activities during the past year. Mr. Manwaring included in his presentation slides of some of the offices of the new I.E.S. headquarters, which were in the process of being completely redecorated and relighted to Recommended Practice. Complete text of Mr. Manwaring's report will be published in the December 1951 issue of Illuminating Engineering.

President Walter Sturrock presented his Annual Address (see text page 431 September, 1951 IE) which was followed by an address on the Society's aims for 1951-1952 by President-elect S. G. Hibben (see text page 434 September, 1951 IE).

Mr. Arthur A. Brainerd presented a most interesting account of the meeting of the Commission Internationale de l'Eclairage held in Stockholm, Sweden last June and July.

Another interesting feature at the opening session, was the presentation by President Sturrock of an illuminated certificate to the National Bureau of Standards on the occasion of their 50th anniversary. Dr. Wallace R. Brode accepted the certificate for the Bureau.

Lighting Service Forum

The scope of the Lighting Service Committee (Lee Tayler, Chairman) as published is "to stimulate discussion and technical applications of lighting recommendations, etc. etc." They did indeed stimulate discussion. The Lighting Service Forum presentations have been growing in popularity year after year—it is getting to be one of the Conference "musts" for wives as well as delegates. This year's show will add to that popularity, without a doubt. A more entertaining manner of getting across sound factual information on Planned Lighting, and how the Industry and the Society serves the country, is difficult to imagine.

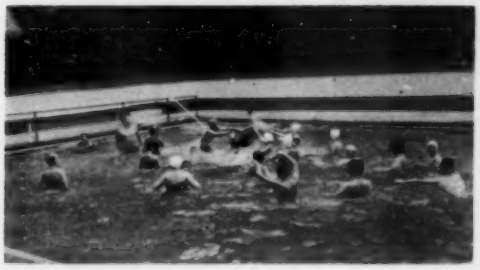
This year's inspired committee presented a production called "Subpoened." The audience (standing room only) were

Upper left, Dr. W. A. Brode of National Bureau of Standards, accepts Anniversary Certificate from Pres. Sturrock. Lower left, S. G. Hibben pins Past-President's emblem to lapel of Mr. Sturrock. Directly above, scene on boat trip to Mt. Vernon.

Conference Highlights

At left, "Mystery Witness" Pres. Sturrock is congratulated by Senate Investigating Committee as finale of Lighting Service Forum program. Below, head table as regrouped by the photographer. Pres. Sturrock, center, is flanked by George Clark, Chairman of the Conference, and Mrs. Clark.

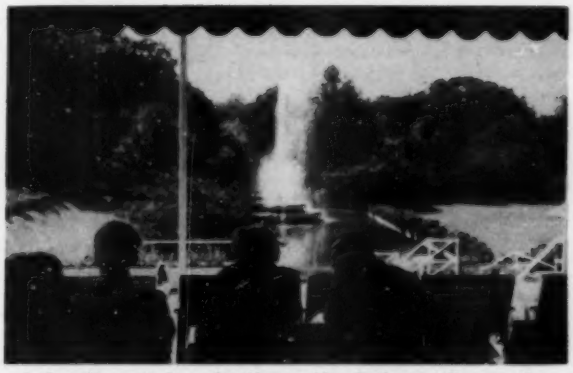
One of the many breakfast committee meetings held during the Conference is shown at left. In this case the Publications Committee with (left to right) R. G. Slauer, E. H. Church, H. H. Magdsick, J. M. Stedman, Ruby Redford, R. W. McKinley and C. E. Ellis. Absent was E. C. Huerkamp, Chairman. Teenagers are shown below, at a Splash Party and in a group.



President Law Golf Trophy is presented to M. L. Bettinger, winner, during ceremonies at Banquet.

Membership Campaign checks are presented to C. B. Pederson, C. N. Laupp and M. L. Bettinger.

Gavel Award is accepted for New Orleans Section, this year's winner.



A favorite spot for relaxation and/or business talk was the Shoreham's spacious verandah.

The flash bulb erased the punch from this picture of a scene during the finale of the Progress Report. In the demonstration of black light, only sox, ties and caps, and/or sweaters and shorts of the participants were visible.

all subpoened to attend a Kefauver-like Senate Investigation of what the Society does and how lighting benefits the nation. Like the Progress Report, this show ought to go on the road—it entertains while it educates.

The Investigating Committee was comprised of: Senator Lee E. Taylor (R-Mich.), Chairman; Senator Clarence Berry (Maryland); Senator J. M. Stedman (Pennsylvania); Senator J. F. Schuchert (Pennsylvania); Senator James Duffy (Massachusetts). Investigating Attorney was Don P. Caverly.

While Attorney Caverly and the Investigating Senators frequently made witnesses squirm with their penetrating loaded questions about the Society's work, on the whole the I.E.S. and the Lighting Industry gave a good account of itself. Most incriminating evidence seems to be that the members of that fraternity were guilty of too much "talking to themselves" and not sufficient dissemination of information on their good work and committee findings to the general public. The Washington Senators, it turned out, had never even heard of the Illuminating Engineering Society.

The entire proceedings were broadcast to the world via radio and television (mock-up equipment). The TV camera was under the direction of R. G. Slauer, with the noted radio analyst being played by Norman Barnes.

Others in the cast included:

Court Attendants—Tom Murphy and Donald Faust
Press Photographer—Berlon Cooper
Court Clerk—Gleason Solly
Court Stenographer—Ruby Redford
Page—Dick Carney

Witnesses (In order of appearance)

1. Industrial Lighting
   a. Safety—Robert Zahour
   b. Protective—George Bogard
2. Street & Highway Lighting
   E. M. Zabel
3. Office Lighting
   Harry Grattan
4. School Lighting
   Roy Palmer
5. Home Lighting
   Katharine Goodall
   Jan Reynolds
   Myrtle Fahsbender
   Gene Commery
6. Training & Education
   Paul Hildebrand
7. Commercial Lighting
   Roger Maynard
8. Fixture & Lamp Manuacturers
   Jim Forbes
9. Mystery Witness
   President Walter Sturrock
10. Sergeants at Arms
    Otto C. Nord
    William Heiss

Technical advisor for the production was George Younglove.

The excellence of the performance given by all of the cast was undoubtedly due to the very able stage direction of Mrs. G. Allison Long who rehearsed them over and over all Saturday evening and all day Sunday.

Daily Newspaper

A daily newspaper titled *Highlights and Reflections* came out early every morning during the week of the Conference, put out during the small hours of the night before by the Conference's Publicity Committee, Harry Grattan, Jr., Chairman, and A. A. Fox, Committee member as Editor. This daily sheet mimeographed under an attractive masthead, was one of the most useful things supplied to delegates. With so many activities, some conflicting as to time, many desirable features could have been missed without this daily reminder of what committee meetings were scheduled and where, deadlines for picking up tickets, starting time of various Sessions, listing of tours, etc., etc. The sheet also included amusing items about the Conference, and all kinds of information of interest to delegates. Hard work but a most worthy project for all Conferences of this size.

Entertainment

There is a hazard, in reporting on the entertainment features available at the Washington Conference of giving the impression that no work was done. With 45 papers, 15 technical sessions, and dozens of committee meetings, this was far from the case. Nevertheless, for visiting ladies and delegates between sessions and during the evening, a very fine entertainment program had been planned by the Ladies Reception Committee, Mrs. Audrey Gibson, Chairman.

An informal greeting party started it off Sunday afternoon, held in the beautiful enclosed sunporch of the Shoreham. Trips were available to the Electric Playhouse, the Pageant "Faith of Our Fathers," a grand tour of historical sites including Arlington, a tour of several foreign Embassies, Washington Cathedral and numerous others.

A ladies luncheon was held Tuesday noon at which the speaker was Mrs. Savilla M. Simons, Assistant Chief of the Health, Manpower and Education Division of the Technical Cooperation Administration of the Department of State. Mrs. Simons' subject was "Human Welfare in Our Foreign Policy."

Also on Tuesday afternoon, some 100 ladies had tea at Blair House, temporary home of President and Mrs. Truman. In Mrs. Truman's absence the ladies were received most charmingly by Mrs. Alben Barkley, wife of the Vice-President.

Almost the entire Conference adjourned Wednesday afternoon to take a three-hour boat trip cruising down the Potomac to Mount Vernon, home of George Washington. The trip included over an hour's stop-over at this national shrine to go through the mansion and roam through the beautiful gardens.

Highlight of the entertainment program was the President's Reception and Banquet held Thursday evening. The setting was outdoors on the terrace of the Shoreham, at the edge of the hotel's

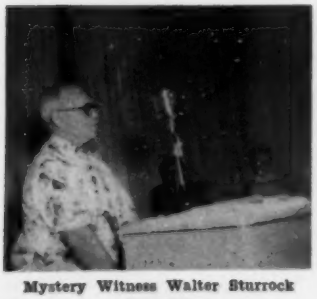
Personalities Seen in Washington

Dick Slauer as cameraman at the Service Forum play.

George Ainsworth arrives.

Some people never stop working. A. A. Brainerd and L. E. Barbrow check discussions while cruising the Potomac.

R. F. Hartenstein, National Conference Chairman, W. A. Brode, National Bureau of Standards, G. W. Clark, local Conference Chairman.



Mystery Witness Walter Sturrock testifies.

spectacular colored fountain. As promised, the stars were out overhead, the evening was balmy, neither too warm nor too cool. A beautiful setting for a delightful party.

AWARDS

Several awards were made during the ceremonies at the Banquet. Chief among these was the presentation of the Past-President's Pin to Walter Sturrock. The pin was placed on his lapel by the incoming President Samuel G. Hibben.

Both Mr. Sturrock and Mr. Hibben were also presented with gifts in appreciation of their services to the Society. Mr. Sturrock received from the Capital Section an ash tray carved from wood from the White House, engraved with the commemorating date and Mr. Hibben was presented with a gavel also of wood from the White House.

The Chicago Section, who will be host to the next Conference, presented one pipe of a set of two to Mr. Hibben, its mate to be received next year in Chicago.

Gavel Award

An attendance gavel and anvil (the latter a gift of the British Columbia Section, 1948 winner) is awarded each year to the section or chapter having traveled the farthest in the greatest numbers, in percentage of the total group membership. This year's winner was the New Orleans Section. Runners up were the St. Louis Section in second place, Georgia Section, third; and Chicago Section, fourth.

Membership Awards

Winners of the Membership Campaign for 1950-1951, under the general direction of James H. Hull of Des Moines, Iowa, Chairman of the Membership Committee, were announced at the Banquet. The competition is held between sections and chapters, based on a prescribed formula of a membership quota of 20 per cent for chapters three years old or less and 12½ per cent for sections and chapters over three years old. The campaign is held in two parts, for total membership, and election to member grade.

In the Total Membership Campaign, first prize of $50.00 went to the Northwestern Ohio Chapter. Mr. M. L. Bettinger, Chairman of that Chapter's Membership Committee, received the prize check from Mr. Sturrock for his Chapter.

Second prize of $40.00 was awarded to Milwaukee Section. Mr. Charles N. Laupp, Chairman of the Milwaukee Section, accepted the check for his group.

Third prize in the Total Membership Campaign, totaling $22.50, was awarded

to the Chicago Section. Mr. C. B. Pederson, Chairman of the Chicago Section received the check.

In the Campaign for Member Grade, two sections tied for first place. Half of the total award of $50.00 went to the Rocky Mountain Section and half to the San Jacinto Section. Mr. H. P. Rankin accepted the check for $25.00 for the Rocky Mountain Section. Mr. Floyd A. Covington, Southwestern Regional Vice-President, accepted the check of $25.00 for the San Jacinto Section.

Golf Award

The I.E.S. President's Cup for Golf Competitions at I.E.S. Conferences was won this year by Mr. M. L. Bettinger of the Northwestern Ohio Chapter. This trophy was presented to the Society by Clarence L. Law, President of the Society in 1923–1924. The trophy is placed in competition at each National Conference and on an 18-hole handicap basis. It was first won by George Ainsworth at the Briarcliff Convention in 1924. Among the 19 winners of the cup are: L. F. Heckmann, Toronto Convention 1928; Lester H. Graves, Swampscott 1932; Kirk M. Reid, Lake Delavan 1933; S. G. Hibben, Baltimore 1934. H. A. Auchter, New Orleans 1947. The cup was won in 1949 in French Lick by Keith Nesbitt of the Cleveland Section. There was no competition for the cup in 1950 at Pasadena.

Other golf prize winners were Mrs. Eugene Beggs, Brooks Chassaing of the St. Louis Section, Lew Moore of the Ohio Valley Section and his wife Mrs. Moore. Joe Bachman, Chairman of the Sports Committee presented the prizes to these winners after the Banquet.

Teenager Program

About 59 teenagers, sons and daughters of delegates, attended the Washington Conference. These young folks had a wonderful time, thanks to an excellent program all planned out for them by a special committee headed by Mrs. J. P. Bachman and Mrs. L. E. Barbrow, Co-Chairmen. Other members of the Teenagers Program Committee were: Mrs. George W. Clark, Mrs. Benjamin Goodman, Miss Bayla Goodman, Miss Anne Goodman, John Bachman, Harry Grattan, III, and Michael Wueste.

The young "delegates" had a room all to themselves as headquarters. Here they had a television set, record player, cards and tables, comic books, magazines, bulletin board and every convenience of a headquarters office. They all checked in here daily to make plans and get in touch with one another.

The teenager program included a Splash Party at the Wardman Park outdoor pool; a picnic in Rock Creek Park, including badminton and baseball (for which the Washington Park Commission furnished equipment). A tour of the F.B.I. was made Wednesday morning during which guards showed the group the Bureau's facilities for crime detection. In the basement, a G-man fired two guns to demonstrate the type of arms used and where the men practice marksmanship.

On the boat trip to Mount Vernon, the teenagers stuck together in their own party, singing all the way.

On Tuesday they made a tour of Washington, having lunch at the Supreme Court Building.

At the Banquet, all dressed up in formal clothes, they had their own table.

Conference Attendance During Last Ten Years

1942	St. Louis, Missouri (2-Day	516
1943	New York, New York (1-Day)	126
1944	Chicago, Illinois	721
1945	No Convention	
1946	Quebec, Quebec	807
1947	New Orleans, Louisiana	605
1948	Boston, Massachusetts	906
1949	French Lick, Indiana	668
1950	Pasadena, California	556
1951	Washington, D. C.	765

Conference Statistics

Official registration of the 1950 Conference was 765. Of the Society's 50 Sections and Chapters, 39 were represented in attendance. One member each came from Honolulu and Bermuda and 24 from Canada, 19 of these from the Toronto Section. One member (Elmer Smith), from the Puget Sound Section traveled over 3,000 miles, farthest of any Section or Chapter delegate. New York had the largest number registered with 81 members, Chicago Section next with 54 members.

Special Acknowledgments

Acknowledgment and thanks should go to the companies by whom the many committee workers for the Conference are employed. The time and facilities thus donated made the Conference the success it was. Splendid local guidance and direction was given to the Conference by Mr. G. W. Clark of the Sylvania Electric Products, Inc., as Chairman of the Conference Executive Committee. Mr. R. F. Hartenstein of the Ohio Edison Company as National Chairman of the Conference Committee gave unstintingly of his time and efforts.

Special acknowledgment should go to every member of the many committees planning and executing this Conference. For the record, some of the members who contributed time and talent to the success of the Conference are:

National Technical Conference Committee

R. F. Hartenstein, Chairman; H. P. Steele, Vice-Chairman, W. C. Brown, R. W. Butts, George W. Clark, J. C. Forbes, A. D. Hinckley, D. W. Prideaux, J. S. Schuchert, L. E. Tayler, M. N. Waterman, F. I. Wilson.

Papers Committee

Hoyt P. Steele, Chairman; H. W. Horn, Vice-Chairman, R. D. Bradley, P. H. Hildebrand, Caroline E. Horn, R. W. McKinley, K. M. Reid, H. L. Wright, R. R. Wylie, R. M. Zabel.

Lighting Service Committee

L. E. Tayler, Chairman; Norman H. Harms, C. J. Berry, George T. Bogard, D. P. Caverly, J. C. Forbes, Katherine T. Goodall, H. Grattan, Jr., P. H. Hildebrand, Paul F. Kyack, Roger Maynard, Roy A. Palmer, G. Wilson Younglove, R. L. Zahour.

Conference Executive Committee

George W. Clark, Chairman; Louis E. Barbrow, Vice-Chairman; Harold V. Oerting, Secretary; J. S. Schuchert, Regional Vice-Presi-

Hard-working member, Berlon Cooper of McGraw-Hill, who together with R. C. Blatt took over 300 pictures at the Conference for the Scrap Book and Journal.

Past-President's Luncheon—held during the recent Conference. Around table, l. to r. H. H. Magdsick, L. H. Graves, S. B. Williams, L. E. Tayler, C. H. Goddard, Pres. Sturrock, Pres.-Elect Hibben, A. E. Wakefield, Willard Brown, W. F. Little, Dr. Ward Harrison.

dent; J. P. Bachman, Ernest Boghosian, L. H. Cleary, Carl G. Estabrook, A. L. Gibson (Mrs.), H. Grattan, Jr., H. L. Guiney, H. P. Teele, F. S. Walters, C. S. Woodside.

Attendance and Publicity Committee

H. Grattan, Jr., Chairman; W. A. Anderson, L. E. Barbrow, A. A. Fox, D. C. Freeman, A. J. C. Knudstrup, Crawford Maddox, F. S. Walters.

Entertainment Committee

H. L. Guiney, Chairman; R. V. Gordon, J. C. Melton, A. R. Mitchell, C. W. C. Poole, Paul Norris.

Transportation Committee

Ernest Boghosian, Chairman; W. C. Fisher, A. L. Lewis, H. C. Smith, J. F. Wueste.

Finance Committee

Carl G. Estabrook, Chairman; Claude Engle, Jr.

Ladies Reception Committee

Mrs. A. L. Gibson, Chairman; Mrs. J. P. Bachman, Mrs. L. E. Barbrow, Mrs. E. Boghosian, Mrs. G. W. Clark, Mrs. L. H. Cleary, Mrs. C. G. Estabrook, Mrs. H. Grattan, Jr., Mrs. H. L. Guiney, Miss Louisan Mamer, Miss Dorothy Nickerson, Mrs. H. V. Oerting, Mrs. R. P. Teele, Mrs. F. S. Walters, Mrs. C. S. Woodside.

Lighting and Decoration Committee

L. H. Cleary, Chairman; Claude Engle, Jr.

Sports Committee

J. P. Bachman, Chairman; W. C. Fisher, R. E. Holmes, T. J. Projector, C. S. Woodside.

Reception Committee

R. P. Teele, Chairman; J. A. Bartelt, E. A. Buel, Mrs. V. I. Burns, O. P. Cleaver, J. F. Wueste.

Hotel Committee

C. S. Woodside, Chairman; Registration, C. P. Newbraugh, N. L. Griffin, Technical Sessions, G. A. Long, Jr., West Ballroom, C. A. Douglas, H. C. Smith, C. C. Pickell, G. E. Schraudt, Jr., Main Ballroom, A. J. Buckley, T. J. Projector, Alvan G. Walker, Jr., L. W. Ferguson, Other Functions, R. E. Holmes, Benj. Goodman, T. F. Stenson.

Program of Technical Sessions

Opening Session

Monday, August 27, 1951

R. F. Hartenstein, *Chairman*

Invocation—Luther D. Miller, Chaplain (Maj. Gen. U.S.A. ret.), Canon of the Washington Cathedral).

Address of Welcome—R. Roy Dunn, President, Potomac Electric Power Co.

Report of General Secretary—A. H. Manwaring, Philadelphia Electrical Mfg. Co.

President's Address—Walter Sturrock, General Electric Co.

Our Society in 1951-1952—Samuel G. Hibben, Westinghouse Electric Corp.

Highlights of the C.I.E. Meetings in Stockholm by the President of the U. S. National Committee—A. A. Brainerd, Philadelphia Electric Co.

The National Bureau of Standards—W. A. Brode, National Bureau of Standards.

Announcements by Chairman, Conference Executive Committee—George W. Clark, Sylvania Electric Products Inc.

Technical Session—General

Monday Afternoon, August 27, 1951

G. W. Beals, *Chairman*

R. D. Bradley, *Discussion Organizer*

Fundamentals of Lighting Cost Analysis—A. C. Barr, C. L. Amick, General Electric Co.

Modern Concepts of Lighting Economics—Fred J. Vorlander, Champion Lamp Works.

Coefficients of Utilization for Luminaires with Concentrating Distributions—J. R. Jones, John J. Neidhart, Westinghouse Electric Corp.

A New Laboratory for Lighting Design Data—W. M. Potter, Anson H. Russell, General Electric Co.

Verification of the Interflection Tables—Russell D. Churchill, General Electric Co., Russell C. Putnam, Case Institute of Technology.

Maintenance of Industrial Lighting—C. E. Egeler, R. F. VandenBoom, General Electric Co.

Technical Session (Parallel)—Sources

Monday Afternoon, August 27, 1951

Norman Macdonald, *Chairman*

Kirk M. Reid, *Discussion Organizer*

Operating Characteristics of Electro-luminescent Lamp—Charles W. Jerome, C. Bernard Stiles, Sylvania Electric Products, Inc.

Color Correction and Other Important Improvements in Mercury Lamps—H. D. Fraser, W. S. Till, Westinghouse Electric Corp.

Factors Affecting Performance of Indicator Lamps—H. M. Ferree, J. D. Lash, General Electric Co.

Low Pressure Mercury Discharges — George Meister, Thomas H. Heine, Westinghouse Electric Corp.

Mercury Vapor Lamp Circuits—C. H. Burns, G. A. Freeman, D. W. Rowten, Westinghouse Electric Corp.

Starting Fluorescent Lamps at Low Ambient Temperatures — R. F. Townsend, H. E. Bachman, Westinghouse Electric Corp.

Lighting Service Forum

Monday Evening, August 27, 1951

Lee E. Tayler, *Chairman*

Technical Session—General

Tuesday Morning, August 28, 1951

R. L. Biesele, Jr., *Chairman*

Robert R. Wylie, *Discussion Organizer*

Photometric Testing by Fluorescent Fixture Manufacturers—E. D. Tillson, Consulting Engineer, Lighting Products, Inc.

An Analysis of Fluorescent Luminaire Brightness Limitations—John J. Neidhart, Westinghouse Electric Corp.

Relation of Distance to Candlepower Distribution from Fluorescent Luminaires—Caroline E. Horn, William F. Little, Ernest H. Salter, Electrical Testing Laboratories, Inc.

Glass Block Fenestration and the Interflection Method, D. E. Spencer, University of Connecticut, V. J. Stakutis, Brown University, H. F. Kingsbury, R. W. McKinley, Pittsburgh Corning Corp.

Object-Color Changes from Daylight to Incandescent Filament Illumination (I.E.S. Research Fund Report), Dr. Harry Helson, University of Texas, Deane B. Judd, National Bureau of Standards, Martha H. Warren, Brooklyn College.

Technical Session (Parallel)—Aviation Lighting

Tuesday Morning, August 28, 1951

L. B. Moore, *Chairman*

D. C. Miller, *Discussion Organizer*

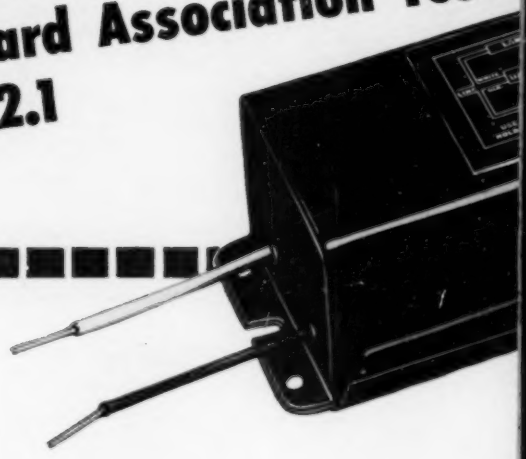
Visual Problems in Aircraft Lighting—Fred R. Brown, David Alsher, Aero Medical Equipment Laboratories, Naval Experimental Station, Philadelphia.

Visual Aids for Airport Ground Traffic Control—Martin A. Warskow, Port of New York Authority, Airport Engineering Division.

(Continued on page 15A)

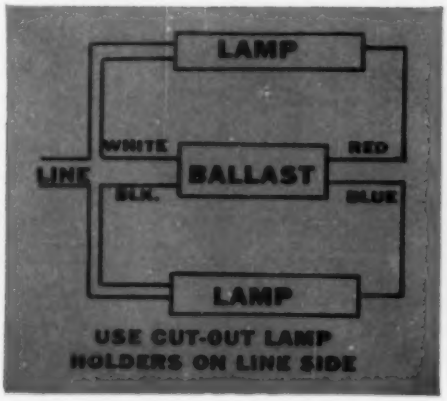
NEW JEFFERSON SERIES

Meets All Requirements of Proposed American Standard Association Test Specification C82.1



Ask for
JEFFERSON
254-511 Ballast
430 MA
118 Volt, 60 Cycle

For *Improved* Operation of Two 96T12 Fluorescent Lamps in Series



The new Jefferson Ballast for 96T12 Lamps is compact, lighter weight, quiet, and cool operating. The unique new design assures longer ballast life, greater lamp life, and better all around fixture performance and user satisfaction.

***POSITIVE STARTING**—even at voltages as low as 106 Volts—with no detrimental effect to lamp life.*

POSITIVE STARTING

SEQUENCE BALLAST

CERTIFIED E·T·L

Member, Certified Ballast Manufacturers

Unique Design Insures Rated Lamp Life and Light Output

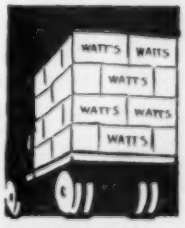
Over 35 years of specialized research engineering, and transformer manufacture has resulted in a unique basic design which assures maximum light output, full rated lamp life and no noticeable variations in brilliancy of the two lamps.

Cool and Healthy

With full wattage delivered to the lamps, the temperature of the Jefferson Ballast remains low—well within the A.S.A. limits for temperature rise. A cool ballast means long healthy ballast life and better lamp performance.

Full Rated Wattage Delivered—Lower Loss

Maximum wattage is delivered to both lamps, yet ballast operating temperature is held to a minimum. Results are unlimited ballast life and greater lamp brilliance. Efficiency is indicated by a wattage loss of only 29 watts.



No Hum to Bother You

Here again unique design and construction features along with traditional Jefferson manufacturing skill eliminates audible hum.

JEFFERSON ELECTRIC COMPANY • Bellwood, Illinois

In Canada: Canadian Jefferson Electric Co., Ltd., 384 Pape Ave., Toronto, Ont.

JEFFERSON
SERIES SEQUENCE
BALLASTS

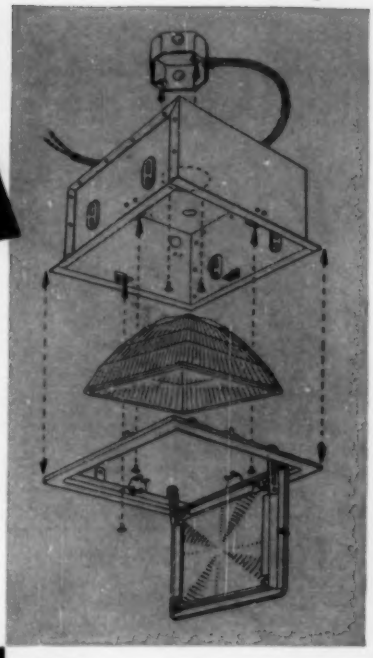
Write for Bulletin 351-11 for complete details on the new Jefferson Series Sequence Ballast.

The LIGHT-TIGHT DUO-FRAME

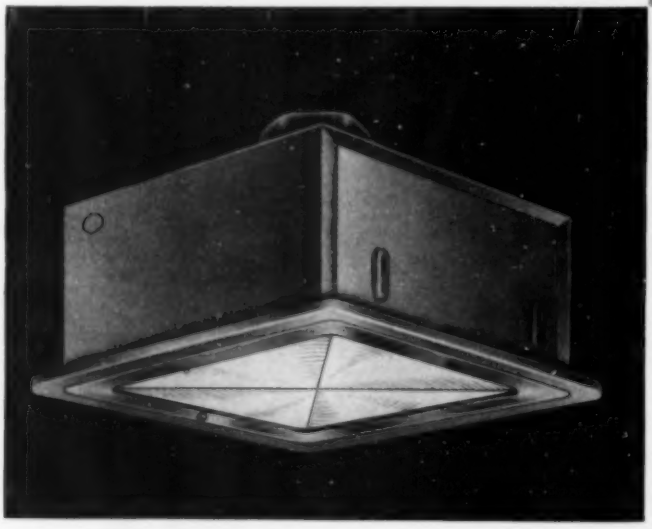
DAY-BRITE'S newest recessed lighting units

PREVENT DAMAGED CEILINGS...

MAKE LIGHT LEAKS IMPOSSIBLE...



Just mount these handsome, new Day-Brite fixtures and stop worrying about ceiling damage, paint scrapes, or unsightly finger marks . . . caused during installation, cleaning or re-lamping. Day-Brite's Duo-Frame brings you these advantages because the Duo-Frame is simply . . . two frames! The outer frame is fastened to the box after painting and plastering have been completed, and it remains in position during servicing. The inner frame, mounted to drop hinges, is easily removed for servicing. And this exclusive Day-Brite light-tight engineering eliminates all light leakage.



30 GREAT FEATURES INCLUDE:

Holophane Controlens* for maximum efficiency, even illumination and low brightness.

Die-formed, riveted and welded construction throughout.

Two sizes: Available for 8½" and 12" square Holophane Controlens,* vertical or horizontal lamp mounting.

Frame finished in Hot-Bonded Lustre Aluminum Enamel, rust-inhibited before painting.

For complete information on the new Duo-Frame write Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis, Mo.

*The Holophane Co.

NOW, MORE THAN EVER

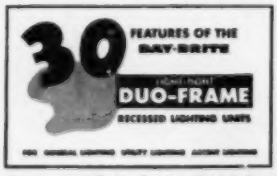
AMERICA MUST SEE WHAT IT'S DOING

IT'S EASY TO SEE WHEN IT'S

"DECIDEDLY BETTER"

DAY-BRITE

Lighting Fixtures



162

For a quick look at all 30 big features ask for this free booklet.

(*Continued from page* 11A)

Are Present Lighting Aids Adequate for Private Flying!—Robert C. Blatt, McGraw-Hill Publishing Co.

Technical Session—Glare and Comfort

Tuesday Afternoon, August 28, 1951

S. B. Williams, *Chairman*

H. P. Steele, *Discussion Organizer*

BCD Brightness Ratings in Lighting Practice—Sylvester K. Guth, General Electric Co.

The Evaluation of Visual Comfort Data—H. L. Logan, A. Lange, Holophane Co., Inc.

Appraisal of Discomfort Glare on Lighted Streets—Kirk M. Reid, D. A. Toenjes, General Electric Co.

The Threshold of Discomfort Glare at Low Adaptation Levels, R. C. Putnam, Case Institute of Technology, R. E. Faucett, Civil Aeronautics Administration, Indianapolis.

Seeing Against Headlamp Glare—V. J. Roper, G. E. Meese, General Electric Co.

The Effect of Spectral Composition of Illumination on Visual Performance (I.E.S. Research Fund Report), Donald Y. Solandt, University of Toronto.

Work, Vision and Illumination—Dr. Ernest Simonson, Dr. Josef Brozek, University of Minnesota.

Military and Civil Defense Lighting

Tuesday Evening, August 28, 1951

Outline of Activities of I.E.S. Coordinating Committee for National Defense, A. F. Wakefield, Co-Chairman

Artificial Illumination of Ground Areas in Combat Zones—L. R. Noffsinger, Engineering Research and Development Laboratories, Ft. Belvoir, Va.

Civil Defense in Atomic Warfare—Capt. Wm. Kratz, Engineering Research and Development Laboratories, Ft. Belvoir, Va.

What the Civil Defense Administration Wants from Illuminating Engineers—Col. Justice Chambers, Federal Civil Defense Administration.

Protective Lighting for Defense Plants—J. W. Lee, Chairman, Committee on Protective Lighting, I.E.S.

Detection and Imaging by Means of Infra-red Radiation—John A. Bartelt, Engineering Research and Development Laboratories, Ft. Belvoir, Va., C. W. Woodside, Bureau of Ships, Navy Department.

Psychological Warfare—Methods of Communication with the Enemy and Their Effectiveness—Lt. Col. J. K. Norris, Chief, Materials Branch Requirement Division, Department of the Army, Office of the Chief of Psychological Warfare.

Technical Session—General

Wednesday Morning, August 29, 1951

Willard C. Brown, *Chairman*

Howard L. Wright, *Discussion Organizer*

Fluorescent Lamp Performance on Sequence-Start Ballasts—D. D. Hinman, R. L. Keiffer, C. E. Strecker, General Electric Co.

Stroboscopic and Flicker Effects from Fluorescent Lamps—Arthur A. Eastman, John H. Campbell, General Electric Co.

The Cost of Seeing a Critical Industrial Task—Willard Allphin, Sylvania Electric Products, Inc.

Noise in Gaseous Discharge Lamps—J. Warren Culp, Sylvania Electric Products, Inc.

Television Interference from Filament Lamps—H. E. Schuls, D. D. Kershaw, General Electric Co.

(*Continued on page* 16A)

LIGHTING CALENDAR

Society Events

November 8, 1951—Meeting of I.E.S. Council Executive Committee.

December 13, 1951—Meeting of I.E.S. National Council, New York, N. Y.

January 10, 1952—Meeting of I.E.S. Council Executive Committee.

February 14, 1952—Meeting of I.E.S. National Council, New York, N. Y.

March 13, 1952—Meeting of I.E.S. Council Executive Committee.

March 13-14, 1952—South Pacific Coast Regional Conference, Hotel Sir Francis Drake, San Francisco, Calif.

March 20-21, 1952 — Pacific Northwest Regional Conference, Hotel Victoria, Vancouver, B. C.

March 31, 1952—Meeting of I.E.S. National Council, Chicago, Ill. (Tentative).

April 6-8, 1952—Southwestern Regional Conference, Hotel Tulsa, Tulsa, Okla.

April 20-22 1952—Southern Regional Conference, Hermitage Hotel, Nashville, Tenn.

April 30 - May 2, 1952—Canadian National Conference, Hotel General Brock, Niagara Falls.

May 5-6, 1952—Great Lakes Regional Conference, Statler Hotel, Cleveland, Ohio.

May 9, 1952—Meeting of I.E.S. Council Executive Committee.

May 22-23, 1952—East Central Regional Conference, Webster Hall Hotel, Pittsburgh, Pa.

June 12, 1952—Meeting of I.E.S. Council, New York, N. Y.

June 19-20, 1952 — Northeastern Regional Conference, Hotel Preston, Swampscott, Mass.

July 10, 1952 — Meeting of I.E.S. Council Executive Committee.

September 8-13, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

October 15-17, 1951 — International Association of Electrical Inspectors, Southern Section, 23rd Annual Meeting, Hotel John Marshall, Richmond, Va.

October 15-19, 1951 — Fall 1951 Convention of the Society of Motion Picture and Television Engineers, Hollywood-Roosevelt Hotel, Hollywood, Calif.

October 22-24, 1951 — National Electronics Conference, Annual Conference, Edgewater Beach Hotel, Chicago, Ill.

October 22-24, 1951—33rd Annual Meeting, American Standards Ass'n, Waldorf-Astoria Hotel, New York, N. Y.

October 22-26, 1951 — American Institute of Electrical Engineers, Fall General Meeting, Hotel Cleveland, Cleveland, Ohio.

October 28-31, 1951—National Association of Electrical Distributors, Board of Governors, The Homestead, Hot Springs, Va.

October 29-31, 1951 — Radio Fall Meeting, Radio-Television Mfgrs. Assn., King Edward Hotel, Toronto, Ont.

November 1-2, 1951 — Conference on Occupational Vision, Atlantic City, N. J.

November 12-15, 1951 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 25-30, 1951 — Annual Meeting, The American Society of Mechanical Engineers, Chalfonte-Haddon Hall, Atlantic City, N. J.

December 2-5, 1951 — American Society of Refrigerating Engineers, 47th Annual Meeting, Hotel Roosevelt, New York, N. Y.

December 5-7, 1951 — Annual Meeting, National Association of Manufacturers, Waldorf-Astoria Hotel, New York, N. Y.

January 6-12, 1952 — The 4th Pan American Congress of Ophthalmology, Del Prado Hotel, Mexico City.

January 12, 1952 — Independent Electrical Contractors Ass'n Inc., Annual Banquet, Hotel Astor, New York City.

January 14-17, 1952 — Plant Maintenance Show, Convention Hall, Philadelphia, Pa.

January 17-24, 1952—National Housewares & Home Appliances Exhibits, Navy Pier, Chicago, Ill.

January 21-23, 1952—National Electric Sign Ass'n, Convention & Exhibit, Hotel Sherman, Chicago, Ill.

January 21-25, 1952—Winter General Meeting, American Institute of Electrical Engineers, Hotel Statler, New York, N. Y.

January 28-30, 1952—The American Society of Heating & Ventilating Engineers, 58th Annual Meeting, St. Louis, Mo.

February 7-8, 1952—Instrument Society of America, New York Section, 1952 Regional Conference on Power Plant Instrumentation, Hotel Statler, New York, N. Y.

March 3-6, 1952—Institute of Radio Engineers, Convention, Waldorf-Astoria Hotel & Grand Central Palace, New York City.

March 5-8, 1952 — Essex Electrical League, Seventh Annual Electrical Industrial Exposition, Terrace Ballroom, Newark, N. J.

March 10-13, 1952 — National Electrical Manufacturers Ass'n, Edgewater Beach Hotel, Chicago, Ill.

March 24-26, 1952—American Society Mechanical Engineers, Spring Meeting, Seattle, Wash.

April 1-3, 1952 — Edison Electric Institute, Sales Conference, Chicago, Ill.

April 1-4, 1952—Greater New York Safety Council, 32nd Annual Safety Convention & Exposition, Hotel Statler, New York City.

April 28 - May 3, 1952 — Chamber of Commerce, Annual Meeting, Washington, D. C.

May 6-9, 1952 — Fourth International Lighting Exposition & Conference, Cleveland Municipal Auditorium, Cleveland, Ohio.

Week of June 9, 1952—44th Annual Convention, National Association of Electrical Distributors, Atlantic City, N. J.

June 23-27, 1952 — Summer General Meeting, American Institute of Electrical Engineers, Hotel Nicollet, Minneapolis, Minn.

August 19-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Ariz.

October 13-17, 1952—Fall General Meeting, American Institute of Electrical Engineers, New Orleans, La.

October 20-24, 1952—40th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 10-13, 1952—National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

January 19-23, 1953—Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 9-12, 1953—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

Week of May 24, 1953—45th Annual Convention, National Association of Electrical Distributors, Stevens Hotel, Chicago, Ill.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953—Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953—25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

November 9-13, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

(*Continued from page 15A*)

Floodlights at Work — Frank R. Jeffrey, Crouse-Hinds Co. of Canada, Ltd.

A Method of Calculating Direct Illumination from Linear Sources—Robert G. McPhail, Holophane Co., Inc.

Technical Session (Parallel)—Residence Lighting

Wednesday Morning, August 29, 1951

Myrtle Fahsbender, *Chairman*

Caroline E. Horn, *Discussion Organizer*

The Photography of Residential Artificial Lighting Effects — E. W. Commery, T. Knowles, General Electric Co.

A Basis for Predicting General Room Illumination in the Home — Priscilla Prenbrey, Edith L. Buchholtz, Westinghouse Electric Corp.

Proposed Designs for Lighting Education in Home Economics Colleges—Kaye A. Leighton, General Electric Co.

The Control Aspects of Residence Lighting—Jan Reynolds, Sylvania Electric Products, Inc.

Progress Report

Wednesday Evening, August 29, 1951

Alston Rodgers, *Chairman*

Technical Session—Street Lighting

Thursday Morning, August 30, 1951

Rolland M. Zabel, *Chairman* and *Discussion Organizer*

Street Lighting—Traffic Accidents—Crime—T. J. Seburn, City Traffic Engineer, Kansas City, Mo.

A Small, Portable Street Lighting Evaluator—G. A. Horton, Westinghouse Electric Corp.

Brightness Patterns on Pavements with Elongated Light Sources—L. J. Schrenk, Public Lighting Commission, Detroit, Mich.

How to Measure Pavement Surface Reflectance (I.E.S. Research Fund Report)—Prof. J. O. Kraehenbuehl, University of Illinois.

Preliminary Analysis of Pavement Reflectance Data—Street Lighting Research Sub-Committee.

I.E.S. Regional Conferences, 1951-1952

Region	Place	Date
South Pacific Coast	Sir Francis Drake Hotel San Francisco, Calif.	March 13-14
Pacific Northwest	Victoria, B. C.	March 20-21
Southwestern	Hotel Tulsa Tulsa, Okla.	April 6-8
Southern	Hermitage Hotel Nashville, Tenn.	April 20-22
Canadian	General Brook Hotel Niagara Falls, Ont.	April 30 - May 2
Great Lakes	Statler Hotel Cleveland, Ohio	May 5-6
East Central	Webster Hall Hotel Pittsburgh, Pa.	May 22-23
Northeastern	Hotel Preston Swampscott, Mass.	June 19-20

Residence Lighting Forum (Parallel)

Thursday Morning, August 30, 1951

Jan Reynolds, *Chairman*

A Progress Report on Residence Lighting Forums, by the Committee Chairmen—Jan Reynolds, Sylvania Electric Products, Inc.

How to Give Your Recreation Room "The Light Touch"—Mary Taepke, Detroit Edison Co.

Lighted Walls and Windows—Key to a Significant Lighting Trend—Kaye Leighton, General Electric Co.

A Tennessee Home in a New Light — May Love Gale, Tennessee Valley Authority.

Home Lighting in Europe as I Saw It — Myrtle Fahsbender, Westinghouse Electric Corp.

Technical Session—Government

Thursday Afternoon, August 30, 1951

G. T. Morrow, *Chairman*

Paul H. Hildebrand, *Discussion Organizer*

U. S. Department of Agriculture's Researches with Light—Knox T. Hutchinson, Assistant Secretary of Agriculture, Department of Agriculture, Washington, D. C.

Light, Color and Environment in Government Offices — L. M. Endres, Public Buildings Service, Washington, D. C.

Public Buildings Service in the Lighting Field — Thomas F. Coghlan, Public Buildings Service, Washington, D. C.

Technical Committee Forum

Thursday Afternoon, August 30, 1951

Our Technical Committee Projects and Their Leaders—A Summary of the year's achievements and a report on the work in hand. Samuel G. Hibben, Vice-President, Chairman, Technical Committee Forum, C. L. Crouch, Technical Director.

Closing Session

R. F. Hartenstein, *Chairman*

Report of the Committee on the President's Address.

Report of the Resolutions Committee.

CHICAGO SECTION'S retiring Chairman, C. B. Pederson, presents the gavel to his successor, R. F. Lusk. Left to right are J. R. Chambers, secretary-elect; Mr. Pederson; Mr. Lusk; W. A. Weibel, retiring secretary and newly-elected Vice-Chairman.

Headquarters Entertains Japanese Visitor

Mr. Saburo Ohba, Director of the Ohba Illuminating Laboratory of Japan recently visited the United States, bringing with him greetings from the Illuminating Engineering Society of Japan and, in particular, a message from Dr. Giichi Omoto, President of the Illuminating Engineering Institute. He especially enjoyed the inspection of the Lighting Institute at Nela Park under the guidance of President Walter Stur-

(*Continued on page 18A*)

Delta select Leader fixtures!

DELTA AIR LINES

Leader's OFFICER—Has plastic louver and translucent plastic side panels for efficient light diffusion and beauty of appearance. Precision engineered. Easy to install and service. For 2, 3 or 4 40-watt lamps or Slimline lamps in lengths from 48" to 96".

VL-440

Delta Air Lines Ticket Office
Sheraton-Gibson Hotel,
Cincinnati.

Ray Smith, A.I.A., architect and designer; Fred L. Schille, general contractor; Becker Electric Co., electrical contractor. Fixtures furnished by the F. D Lawrence Electric Co.

Leader fixtures bring distinctive lighting to this new Cincinnati ticket office

LEADERALL moulded plastic ceiling grilles may be suspended at any desired height to form a rigid, level ceiling of light. Use with any type fluorescent fixtures. Do not interfere with air conditioning or sprinkler systems.

Delta Air Lines, in their search for the finest in illumination for their new ticket office in Cincinnati, chose Leader fixtures to provide: 1) optimum light for working surfaces; 2) soft border lighting; 3) spot-lighting; 4) even overall illumination with shielded light source.

The attractive lighting layout involves the use of a variety of Leader fixtures, including OFFICER fixtures, used over the ticket sales counter, and a LEADERALL louvered ceiling for pleasing overall lighting.

If you, like Delta, want the finest in fluorescent lighting, look to Leader . . . first!

Sold and installed by the better electrical dealers and contractors

Leader *America's No. 1 Lighting Equipment Manufacturer*

LEADER ELECTRIC COMPANY • 3500 North Kedzie Avenue • Chicago 18, Illinois

Leader Electric—Western: 800 One Hundredth Avenue, Oakland 3, California
Campbell-Leader, Ltd., Brantford, Ontario, Canada

(Continued from page 16A)

rock. He visited the headquarters office and through the cooperation of the staff obtained information on American practices. Arrangements were made for him to visit various theaters, movie and television studios in the New York area where he observed some of the latest trends in lighting. Equipment manufacturers in this field aided him greatly in contributing design information.

Mr. Ohba has spent 15 years specializing in the study of the emotional value of color. He has prepared a Table of color giving natural objects with which the colors are associated and describing the emotional characteristics of the colors. Mr. Ohba is active in the Japan Theater of Arts Society and the Color Science Society and is a recognized authority as a stage lighting artist.

January 1 Is Deadline for I.E.S. Gold Medal Nominations

Members of the Society are invited to submit, before January 1, 1952, nominations for consideration by the 1951 Medal Award Committee. The I.E.S. Gold Medal is awarded for the purpose of giving recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering. In making nominations for the Award, the following points should be observed.

1. Candidates for the Award need not be members of the Society, nor citizens of the United States or Canada, and may be nominated at any time by any member of the Society, by presenting to the General Secretary at Society Headquarters the name of the individual whose accomplishments, whether it be in the field of engineering, design, applied illumination, optics, ophthalmology, lighting research education, or administration and management.

2. In order for a candidate to be considered for the award of a given year, a letter requesting consideration of the proposed candidate shall be delivered at the General Office before January 1 of that year.

3. Nominations and records on file in the General Office from previous years, as reviewed and referred to the next year's committee by the previous Medal Award Committee, will be given consideration along with any new nominations.

Student Architects Win Awards In Southern California Contest

Awards have been made in a competition sponsored by the Southern California Section, I.E.S., open to all students registered in accredited schools of architecture within the area of the Section. The contest was in cooperation with the Southern California chapter of the American Institute of Architects. The School of Architecture, University of Southern California, supplied the project program of "Lighting a Men's Store." Rules for the competition included designing the complete store with regard to minimum illumination levels consistent with the best current practices; brightness balances for the objectives of efficiency, comfort, atmosphere, etc.; integration of the lighting system with the architectural and decorative design.

The awards were: First prize, $100 to Robert S. Grant; Second prize, $25 to Jack Ouzounian; third prize, $10 to Fred Dinger. In addition to the cash award, each received a Certificate of Merit. Fourth, Fifth and Sixth Place awards of certificates of honorable mention and a one-year student membership in the Society went to George Foy, Victor Spotts and Warren Overpeck.

WINNERS of the 1951 Architectural Student Lighting Design Competition, sponsored by the Southern California Section of I.E.S. Seated, from left to right, Robert S. Grant, Jack Ouzounian, Fred Dinger, winners of the first, second and third prizes. Standing, George Foy, Victor Spotts, and Warren Overpeck, who received certificates of honorable mention.

Libraries of Europe to Receive First Edition Handbooks

The problem of what to do with the copies of the First Edition of the *I.E.S. Lighting Handbook* after the Second Edition supplants it is being solved by Sylvania Electric Products, Inc. They have taken action to suggest to their people that all copies of the First Edition be sent to the libraries of Europe, through the United States Book Exchange, where they can be of use in helping in the reconstruction and relighting of many still devastated areas.

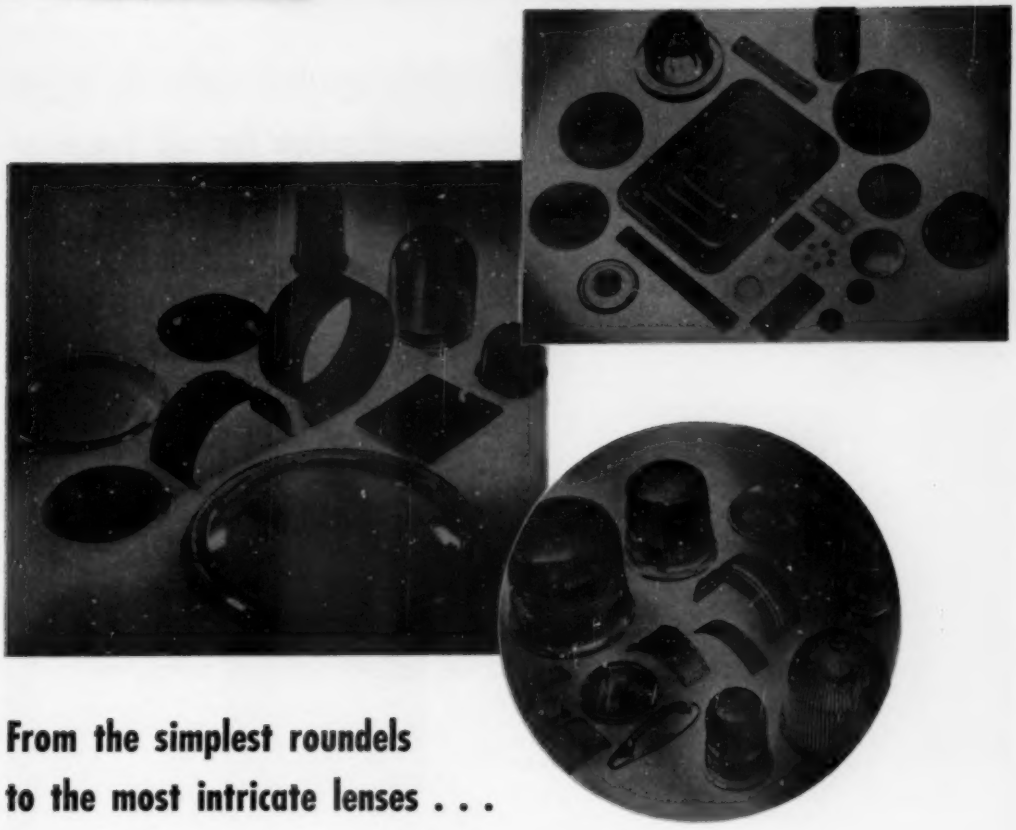
For any others who wish to follow this suggestion, the address to which books should be sent is: The United States Book Exchange, Inc., Library of Congress Building, Washington 25, D. C.

I.E.S. Study Group Active in Tulsa

A very healthy I.E.S. "youngster" has been growing in Tulsa, Okla., for the past five years. Known as the Tulsa Study Group of I.E.S., this body of Society members has been functioning on practically full Section proportions. Example — last year's program included seven meetings with an average attendance of 32, not counting an end-of-the-year picnic. In 1949-50 they held eleven meetings with an average attendance of 53.

Officially members of the Southwestern Section, but too far away for regular attendance, this group organized in 1946, with elected officers and an active

(Continued on page 21A)



From the simplest roundels
to the most intricate lenses . . .

KOPP GLASS

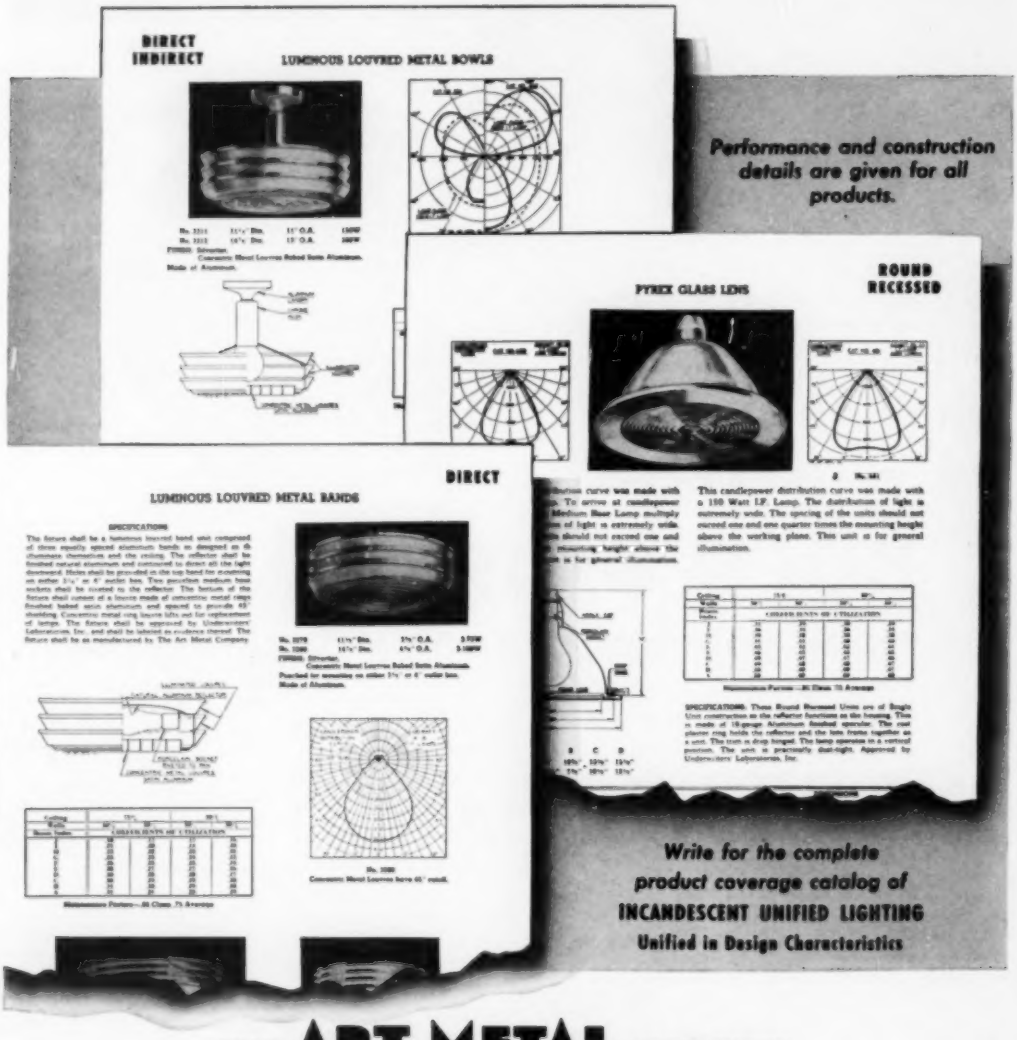
meets your most exacting requirements...

When you specify KOPP lenses, roundels, color filters or other glass parts, you are assured of highest quality. Being specialists in the manufacture of technical glassware for lighting and industrial applications, Kopp provides exceptional engineering, research and production facilities for the design, testing and making of parts to meet your most exacting requirements.

KOPP GLASS

KOPP GLASS, Inc.
SWISSVALE, PA.

ART METAL gives explicit data to speed specification writing and installation planning for all types of INCANDESCENT LIGHTING



THE ART METAL COMPANY

CLEVELAND 3, OHIO

Manufacturers of Engineered Incandescent Lighting

(*Continued from page* 18A)

committee set-up. Their 1951-1952 officers are:

Chairman, Robert G. Smith, General Electric Co.; Vice-Chairman, John E. McCoy, Oklahoma Gas & Electric Co.; Secretary, M. J. Myers, Jr., Public Service Co.; Programs, Dale H. Watt, Watt Plumbing & Electric Co.; Membership, Tom Wier, Bussman Fuse Co.

To provide meeting programs which presented subjects of greatest interest to its members, the Tulsa Study Group recently undertook a survey in which members were asked to check their preferences on a list of 20 different illumination topics. Returns on the survey are being used as the basis for next year's programs. Other Section and Chapter program chairmen may be interested to note the preferences indicated in this survey. The first ten preferred subjects in order of their relative popularity were: (1) Futuristic lighting theory and possibilities; (2) joint meeting with local architects; (3) lamp development and new uses; (4) commercial lighting problems and solutions; (5) manufacturers' discussion of their fixtures' features; (6) industrial lighting problems and solutions (7) joint meeting with local general contractors; (8) engineering layout information and calculation procedures; (9) joint meeting with eye specialists; (10) home lighting course.

OFFICERS of active I.E.S. Tulsa Study Group (l. to r.) John E. McCoy, vice-chairman; Robert G. Smith, chairman; T. C. Wier, membership chairman; Dale H. Watt, program chairman; M. J. Myers, Jr., secretary.

According to a report on the year's activities, submitted by Chairman R. G. Smith at the May meeting, the group is now considering formal petition for I.E.S. Chapter status. The Southwestern Regional Conference is scheduled to be held in Tulsa next spring, and members of the group are hoping that a charter for the Tulsa Chapter will be presented at that time.

NEMA Studies Engineer Shortage

Recognizing the critical shortage of engineers in the electrical manufacturing industry, the Board of Governors of the National Electrical Manufacturers Association has established a five-man committee to study the problem and make recommendations on what can be done. Known as the NEMA Committee on Engineering Talent, the committee consists of:

F. H. Roby, Chairman, Vice-President, Square D Co.
M. M. Boring, Technical Personnel Divisions, Engineering Policy, General Electric Co.
John Bullock, Industrial Relations Division, Allis-Chalmers Manufacturing Co.
H. N. Muller, Assistant to Vice-President of Engineering, Westinghouse Electric Corp.
Harold Winton, Director of Training, United States Rubber Co.

Scope of the committee has been set forth in three points.

"(1) To analyze the situation which faces the industry during the next ten years in the highly competitive recruiting market which will result from the great decrease in the number of graduating engineers.

"(2) To consider and recommend what can be done by NEMA directly with the colleges or by providing information for use of member companies, to bring to the attention of graduates the opportunities available in the electrical manufacturing industry.

"(3) To estimate the probable cost of any program which may be recommended."

British I.E.S. Elects New Officers

The Illuminating Engineering Society of Great Britain has announced the election of new officers. They are as follows:

President—J. G. Holmes
Vice-Presidents—Dr. W. J. Wellwood Ferguson; A. G. Higgins; E. C. Lennox, L. C. Rettig; Dr. W. S. Stiles
Hon. Treasurer—W. J. Jones
Hon. Secretary—H. C. Weston
Hon. Editor of Transactions—Dr. W. E. Harper

In acknowledgment of his eminence in the field of photometry and illuminating engineering, his long, sustained and outstanding service to the Society the Council conferred Honorary Membership upon Dr. John W. T. Walsh.

I.L.E. Merit Award Rules Now Available

New official rules for the $2500 Merit Award Competition, sponsored by the Fourth International Lighting Exposition and Conference, have now been released. In addition to continuing many of the regulations of the last popular competition, several new rules have been added and should prove of special interest.

Requirements for entering have been further simplified and standardized; the total number of Gold Seal Merit Awards has been increased to five in each classification and the cash value of Gold Seal Merit Award prizes has been increased to $2500; and the nature of the material expected from entrants is more specifically defined and provisions are made for even greater recognition and publicity for winning awards.

"For two very important reasons, interest in the new 1952 Merit Award Competition is greater than ever before," says G. T. Morrow, Chairman of the Merit Award Committee. "First, because the previous I.L.E. Merit Award Competitions have established these awards as a mark of distinction and outstanding achievement, they have become the most coveted and highest honor bestowed in the lighting industry.

"Secondly, because of the increasing importance of lighting today to the nation's defense effort, entrants in the competition have the opportunity to make a definite contribution to the nation's welfare. By their submittal of outstanding lighting installations utilizing the most

(*Continued on page* 23A)

(Continued from page 21A)

advanced lighting systems, techniques, equipment and other component parts of good lighting, they help to mobilize lighting knowledge to further defense production and to advance America's welfare."

There are five separate competitions, one for each of the following groups:

1. Electrical Contractors
2. Utility Lighting and Power Representatives
3. Electrical Distributors' Lighting Specialists and Salesmen
4. Architects and Consulting Engineers
5. Owners and Users of Industrial and Commercial Lighting

Judging will be intra-group—that is, a submittal by an electrical contractor will compete with only those of other electrical contractors, etc., and awards will be decided accordingly. In addition, where the installation is the cooperative work of two or more people of the above classifications, the entry may be submitted by the two or more involved as a joint entry and entered in one or more of the applicable classifications.

From the entries received, the Board of Judges will select those which, in the opinion of the judges, are entitled to receive Merit Award Certificates. The number of Merit Award Certificates to be awarded will be entirely in the hands of the judges and will be based on the number of entries regarded by the judges as deserving of such recognition. The judges may, at their discretion, award a Merit Award with Distinction Certificate to those entries which, in the opinion of the judges, are deserving of special recognition.

From the entries selected as deserving of Merit Award Certificates or Merit Award with Distinction Certificates, the judges will select those which in their opinion are deserving of Gold Seal Merit Awards in any one of five classes of installations, as follows:

Not more than five INDUSTRIAL lighting installations may receive a cash award of $100.00 each.

Not more than five SCHOOL lighting installations may receive a cash award of $100.00 each.

Not more than five OFFICE lighting installations may receive a cash award of $100.00 each.

Not more than five STORE lighting installations may receive a cash award of $100.00 each.

Not more than five MISCELLANEOUS lighting installations including street, airport, floodlighting, recreational lighting, protective lighting, etc., may receive a cash award of $100.00 each.

While the competition does not close until midnight, January 31, 1952, entrants are urged to send in at once the entry blank which appears on the back of the Rules Booklet. They will then be sent a registration number to affix to their entry. The names of the participants will thus be unknown to the five impartial judges, assuring absolute fairness in the selection of the winners.

The judges are Carl Zerse, Chairman, Managing Director, Chicago Lighting Institute; Berlon C. Cooper, Eastern Editor, Electrical Construction and Maintenance; John O. Krachenbuehl, Professor of Electrical Engineering and Illumination, University of Illinois; Burr J. Martin, Publisher and Editor, Electrified Industry; and J. Francis McCabe, Superintendent of Buildings, The Art Institute of Chicago.

Awards will be conferred at one of the conference sessions — date to be announced later. Successful entries will be exhibited at the Fourth International Lighting Exposition and Conference, Cleveland Auditorium, Cleveland, Ohio, May 6 to 9, 1952.

Requests for the Official Rules and Entry Blanks should be sent to the Merit Award Committee, 4th International Lighting Exposition and Conference, Room 818, 326 W. Madison St., Chicago 6, Illinois.

Tape Recording Made of Story Of Newly Developed Light

The story of the development of "Mifurba Norlite," the lighting system which can be used to simulate north sky light (see ILLUMINATING ENGINEERING, August issue, p. 389) has been recorded on tape and is, with 36 kodachrome slides available to any of the Sections and Chapters upon request. A transcript of the talk, which takes about fifteen minutes, will accompany the kit for use where a tape recorder is not available. Requests should be made to Floyd Sell, Lighting Division, The Detroit Edison Company, 2000 Second Avenue, Detroit, Mich.

RECORDING the story of the development of "Mifurba Norlite," new light source which simulates north sky light for judging mink and fox furs, are Floyd Sell and Duncan Preston of the Detroit Edison Co.

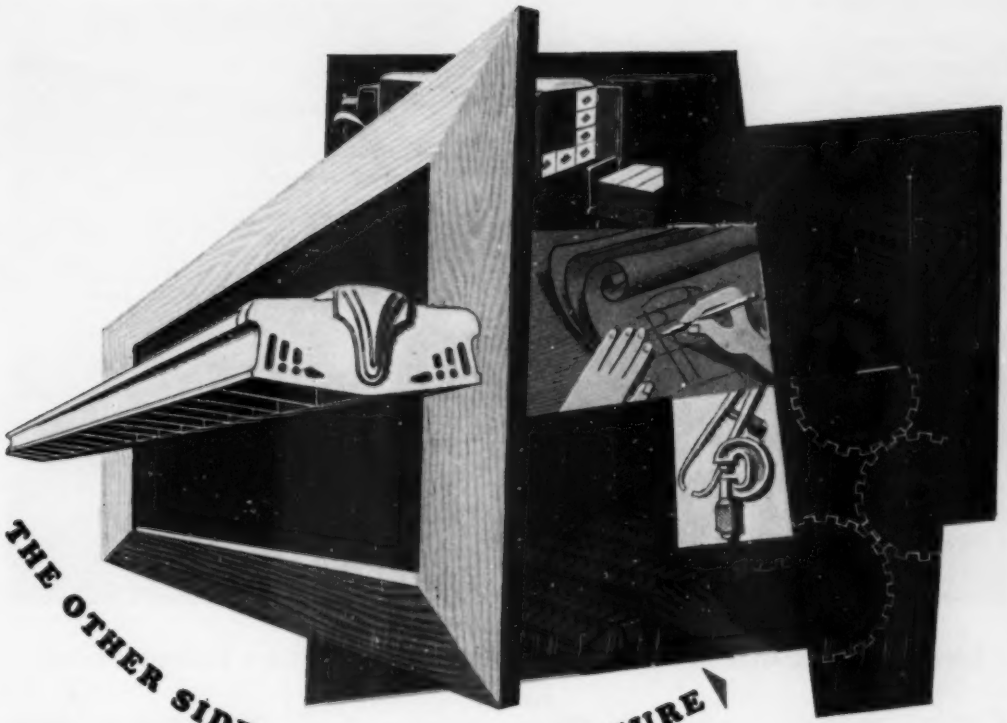
Chicago Lighting Institute Opens Fall Season

The Chicago Lighting Institute, with the Illinois Institute of Technology and the Chicago Section, I.E.S. as co-sponsors, opens its Fall Quarter with four courses: Lighting Salesmanship; Lighting Fundamentals; Residential Lighting; and Wiring Design Number I.

Lighting Salesmanship, with Van L. Phillips as instructor, consists of twelve two-hour weekly sessions, devoted to practical lighting sales methods. Tuition is $20.00.

Lighting Fundamentals is in two parts, Lecture and Laboratory. The Lecture sessions, with Robert Ligare as instructor, are eleven two-hour classes, weekly from October 3 through December 19. The Laboratory sessions are every other Friday under William D. Richards, start-

(Continued on page 25A)



THE OTHER SIDE OF THE GUTH PICTURE

we are big—
—and we are small

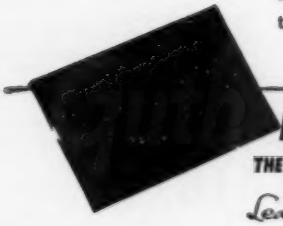
we are big enough to massproduce
any huge installation project—
—and small enough to tailormake that one fixture in
the corner store or the board chairman's glamour office

we are big enough for assembly-line work—
—and small enough to work with you on
any special lighting problem

we are big enough to produce a complete line
of commercial and industrial fixtures—
—and small enough to keep our executives' doors open for
you any time you need help

we are big enough—
—and small enough
to be your friends

E. P. Guth



LIGHTING

THE EDWIN F. GUTH COMPANY / ST. LOUIS 3, MISSOURI

Leaders in Lighting since 1902

G-E "LIGHT CONDITIONING" RECIPE

See what a lighted valance can do for your living room

STRETCH a lighted valance across your living room wall-to-wall and you'll be surprised at how the room seems to grow in size. How it glows with new beauty. How colors stand out in draperies and furnishings, as ceiling and walls are bathed with soft, cool, uniform light from concealed fluorescent lamps.

It's one of the newest ideas in home decoration! Confined at first to the most expensive interiors, lighted valances are now being offered at popular prices to fit any home.

In the interior above, the lighted valance is combined with portable lamps in a typical G-E Light Conditioning recipe:

WHAT TO USE: 20, 25 or 40-watt G-E fluorescent tubes end-to-end to fit valance length.

HOW TO USE: Wall-to-wall as above, or over doors or windows. Valance can be up to 10" deep.

For best results, be *sure* your lamps are marked "G-E".

FREE "LIGHT CONDITIONING" RECIPE BOOKLET. Brand new! Contains 22 Light Conditioning recipes. Covers every room in the house. Specifies bulbs, fixtures, measurements. Write Lamp Division, General Electric Company, Dept. 166-IE-10, Nela Park, Cleveland 12, Ohio.

6TH IN A SERIES!

This is the 6th in a series of full-color ads on Light-Conditioning which is running in LIFE, BETTER HOMES, and the POST. They're helping to bring the Light-Conditioning idea to millions of readers, and improve lighting standards in new homes and old. Tie in with Light Conditioning. Write Lamp Division, General Electric, Nela Park, Cleveland 12, Ohio.

LESS GLARE, SOFTER SHADOWS, are the result of using General Electric's new 100-watt White lamp. Revolutionary new inside "Q" coating, product of G-E research, makes the difference. 100-watt White lamp **21¢** plus tax.

STOP BULBSNATCHING! Don't rob one light socket to fill another. New G-E 4-lamp package makes it easy to keep spare bulbs on hand. Four 60-watt lamps . . . **56¢** plus tax. Four 100-watt lamps . . . **64¢** plus tax.

You can put your confidence in—

GENERAL ELECTRIC

(*Continued from page* 22A)

ing October 5. Tuition covering both parts is $20.00.

Residential Lighting—"Lighting for Living"—consists of six classes by Kerr Sanders, weekly from October 11 through November 15. Tuition is $10.00.

Wiring Design Number I is designed to acquaint the student with the fundamental principles of design and covers residential, commercial and industrial wiring. Frank R. McShane is instructor; classes are weekly from October 2 through December 18; tuition is $40.00.

Additional information on the courses offered can be obtained from Carl W. Zersen, Managing Director, Chicago Lighting Institute, 37 S. Wabash Ave., Chicago.

Fundamentals of Illumination — I.E.S.-A.I.E.E. Sponsored Course

A 12-week educational course on Fundamentals of Illumination is being sponsored jointly by the New York Sections of the Illuminating Engineering Society and the American Institute of Electrical Engineers. A brief resume of the sessions and speakers indicates the coverage given:

October 1 — Theory of Light and Control: Speaker, R. L. Zahour, Westinghouse Electric Corp.
October 8—Illumination Terms: Speaker, R. L. Zahour.
October 15—Filament Lamps and Electric Discharge Lamps: Speaker, R. L. Zahour.
October 22—Fluorescent Lamps: Speaker, L. R. Anderson, General Electric Co.
October 29—Equipment Design: Speaker, R. R. Wylie, Sylvania Electric Products, Inc.
November 5—Effect of Brightness and Glare: Speaker, R. R. Wylie.
November 13 (Tuesday)—Lighting Requirements: Speaker, L. R. Anderson.
November 19 — Illumination Computations: Speaker, L. R. Anderson.
November 26—Light for Production: Speaker, R. R. Wylie.
December 3 — Light for Selling: Speaker, L. R. Anderson.
December 10—Light for Seeing: Speaker, R. L. Zahour.
December 17—Economics of Lighting: Speakers, R. R. Wylie, Sylvania, and H. A. Anderson, Duro-Test Corp.

The classes are being held 6:30-8:00 p.m. in Room 815, The Consolidated Edison Company Building, 4 Irving Place, New York, N. Y. Tuittion to I.E.S. and A.I.E.E. members is $10.00; to all others $20.00.

Dayton Streetlighting Program To Be Completed by June 1952

Described as "one of the most functional in the world," the Dayton, Ohio streetlighting system will be completed by the middle of next year. Filament, sodium, and mercury-vapor luminaires are each applied to best advantage.

Of the 8,000 streetlights, more than half will replace outdated ones, and approximately 3,300 new lights will be installed on primary and secondary thoroughfares and in residential districts.

In the five-square-mile downtown section, 700 new mercury-vapor luminaires are being installed, raising the illumination level from .76 to 3.0 footcandles. The new units, equipped with 20,000-lumen lamps, are spaced twelve to a city block.

On 98 secondary streets, 1,500 luminaires will be installed on existing poles with 10,000-lumen sodium lights at dangerous intersections.

Prominent in the Dayton Power and Light plans is the application of photoelectric streetlighting controls for turning the lights on and off automatically with decrease or increase in daylight.

At a meeting held jointly by the local sections of the I.E.S., and A.I.E.E., the Dayton Safety Council and Engineers Club, Dr. A. F. Dickerson, manager of General Electric's Lighting and Rectifier Divisions, predicted that the new lighting system will reduce night traffic accident rate to the day rate.

I.E.S. Research Fund To Sponsor New Projects

It has been agreed by the Board of Trustees, I.E.S. Research Fund and the Research Executive Committee that Fund Trustees will consider proposals from the Committee to use voluntary earmarked funds to sponsor new specific research projects. This decision opens new horizons for industrial research beyond those which now have precedence.

Also favorably considered were researches through fellowships at the Doctorate level and continued survey of Research Foundations.

ASCE Plans 100th Anniversary Celebration

The year 1952 marks the one-hundredth anniversary of the founding of the American Society of Civil Engineers, oldest national engineering society in the country. Since all engineering societies are, in effect, offshoots of ASCE, they are invited to join in the centennial celebration.

Three features of the program predominate. An international convocation of engineers in Chicago during the period of September 3 to 13, 1952; an exposition centering around the Museum of Science and Industry in Chicago, and carefully prepared literature, moving pictures, radio and television productions.

Major Lenox R. Lohr, president of the Museum of Science and Industry, is president of the corporation set up to arrange for the centennial.

N.P.A. Lamp Manufacturers Advisory Committee Appointed

The National Production Authority, U. S. Department of Commerce, has announced the membership list of the Incandescent and Fluorescent Lamp Manufacturers Industry Advisory Committee as follows:

Dwight H. Marsh, Vice President, Champion Lamp Works, 600 Broad Street, Lynn, Massachusetts

Charles Sabatini, President, Colonial Electric Products, Inc., 1-115 Market Street, E. Paterson, New Jersey

Michael Portnow, President, Dura Electric Lamp Company, 64 East Bigelow Street, Newark, New Jersey

William F. Bayne, Vice President, Duro-Test Corporation, 4161 Hudson Blvd., North Bergen, New Jersey

(*Continued on page* 26A)

AT THE JOINT MEETING of the Board of Trustees, I.E.S. Research Fund and Research Executive Committee were (l. to r.) Dr. Conrad Berens, Alfred H. Nicoll, Dr. B. M. Zabel, Prof. Howard M. Sharp, C. L. Crouch, A. F. Wakefield, Prof. J. O. Kraehenbuehl, Prof. E. M. Strong, C. H. Goddard and Dr. Ward Harrison.

(Continued from page 25A)

R. W. Davis, General Sales Manager, Lamp Department, General Electric Company, Nela Park, Cleveland 12, Ohio

Gustav Herzberg, President, Jewel Products, Inc., 266 Glenwood Avenue, Bloomfield, New Jersey

William Wiel, Secretary & Treasurer, Radiant Lamp Corporation, 300 Jelliff Avenue, Newark, New Jersey

Max Ettinger, President, Save Electric Corporation, 615 Front Street, Toledo, Ohio

Frank J. Healy, Vice President, Lighting Division, Sylvania Electric Products, Inc., Salem, Massachusetts

George W. Keown, General Sales Manager, Tung-Sol Lamp Works, Inc., 95 8th Street, Newark, New Jersey

H. G. Cheney, Assistant Sales Manager, Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey

N.A.E.D. Opens Larger Headquarters in New York

The opening of new and larger headquarters offices by the National Association of Electrical Distributors at Norway House, 290 Madison Avenue, New York City, was announced today by Charles G. Pyle, executive director of N.A.E.D.

Increasing membership in the Association and enlargement of the staff have necessitated the move, Mr. Pyle pointed out.

The new offices are centrally located in the City and are convenient to both railroad and plane terminals. Completely air conditioned, the offices have an outstanding lighting installation incorporating the latest in lighting techniques and fixture design.

IT SEEMS TO ME

Series Ballasts

To the Editor:

The letter from Max K. Aulick, Orlando, Florida, published under "It Seems to Me" in the July 1951 issue of ILLUMINATING ENGINEERING, raises certain embarrassing questions for the manufacturers of fluorescent lamps and lighting equipments. It is a known fact that major troubles have been experienced in certain applications involving the use of fluorescent lamps with series sequence-starting ballasts. I do not believe that any supplier of lamps or ballasts will deny that.

As early as December 1950, one lamp company issued a warning that shorter life might be expected of lamps supplied with series sequence-starting ballasts. Other lamp manufacturers issued similar statements. Investigations were started by both lamp and ballast manufacturers in an effort to learn the causes of the difficulties being experienced.

Joint industry meetings were called and data were presented from many sources. It was found that the factors involved were complex, both in the field and in the laboratories, in lamp design and ballast circuits, requiring considerable time to develop the technical data necessary to point the way to a solution. Situations which served to confuse the problem were discovered and discarded, one example being premature lamp failure caused by failure of wire-men to observe the special wiring connections (shown on nameplate labels) of sequence-start ballasts.

Finally, the industry group, based on test data from several sources, adopted a modification to existing ballast specifications which, it is hoped, will provide the necessary improvements in lamp operating conditions to assure a reasonable life performance. It must be realized that only time can tell what success will result from this move since no way has been found to accelerate the life testing of fluorescent lamps to yield data which might be interpreted in terms of service life.

It might be said that the industry is at fault for putting on the market lighting equipment having the potentialities of troubles reported, that proper safeguards should have been provided. This would be too strong an indictment. The mechanism of lamp starting has been generally understood for some time; however, experience with instant starting lamps has largely been with shock-starting ballasts, where adequate voltage for starting had appeared to be the essential element. Such ballasts inherently provided excess energy for lamp starting processes, making it unnecessary to accumulate data exact enough to define energy requirements for satisfactory lamp starting. Not until these troubles began was there a full appreciation of the energy requirements in starting these lamps. Accordingly, modified specifications now require not only sufficient voltage to initiate the discharge but that there be sufficient energy available to promptly convert to hot-cathode operation. Much has been learned about lamp-starting requirements, but in this case by the unforgettable hard way. — E. H. SALTER, *Research Engineer, Electrical Testing Laboratories, Inc., New York, N. Y.*

Approach Light Tests at the Landing Aids Experiment Station

To the Editor:

It would be unfortunate if the article entitled "Recent Developments in Visual Low-Approach and Landing Aids for Aircraft," which was published in the July issue of ILLUMINATING ENGINEERING, were to go unchallenged. The article states conclusions in a manner that is liable to mislead many readers and it gives the impression that the Pearson-Sweet slope-line approach-light system was originated by one who only recommended a minor improvement in it.

From the conclusions which start on page 357, it might be inferred that the tests made at the Landing Aids Experiment Station proved the slope-line system of approach lights to be definitely superior to any of the other systems tested. This impression derives in part from an association of the 1948 results with systems not tested until 1949 and in part from statements among the "conclusions" that are merely someone's opinions.

It is explicitly stated on page 357 under the heading "Evaluation of Test Findings" that "the 1949 tests were not discussed in detail by Dr. Garbell—." This may well lead the reader to suppose that all the conclusions given in this article are based upon results obtained in 1948 or previous years. The second and fourth paragraphs on page 358, however, refer to the Calvert system as if it had been among systems tested in 1948 and hence among the systems which the L.A.E.S. had found inferior to the slope-line system. The other paragraphs on page 358 seem to support this inference.

No satisfactory embodiments of the center-row principle were tested at the L.A.E.S. until 1949 and the observations at Heathrow were not comparative like those made at the L.A.E.S. In view of this, all the conclusions involving the center-row systems should be taken as opinions, only. With some of these, as for example those stated in the first two paragraphs on page 358, several of the engineers who served on the Airport Lighting Evaluation Panel would definitely disagree.

When the L.A.E.S. results for 1949 are taken into consideration, the picture is decidedly different from that which the reader of this article is liable to form. It was the finding of the group which reviewed the results of this final year's work at Arcata that these results were not decisive. Of 394 test approaches reported for that season, 324 were made with some variant of the slope-line sys-

(Continued on page 28A)

20 MILES OF FIXTURES . . . .

In only six months MORE THAN 2,000* SCHOOLROOMS and many well known offices have been improved by . . .

*Based on shipping records for 6 months

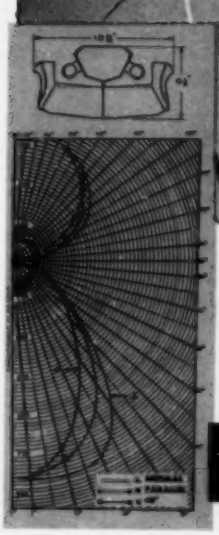
5050 Visualier series available in 4 ft. and 8 ft. units — two lamp rows — fluorescent or slimline — individual mounting or continuous runs. Four lamp matching fixtures also available.

GARCY'S *Visualier*

WHY? Because only Visualier checks "YES" on all these points

- ✔ 45°x45° SHIELDING
- ✔ 50-50 LIGHT DISTRIBUTION
- ✔ 77% LIGHT UTILIZATION
- ✔ Softly illuminated side panels for low surface brightness.
- ✔ Far exceeds I.E.S. and A.I.A. school lighting specifications.
- ✔ All metal construction — no glass or plastic to break or warp.
- ✔ One-piece louver shield — hinged from either side or removable.
- ✔ Large louver cells easily cleaned from floor with brush or vacuum.
- ✔ Couple perfectly for continuous runs.

Literature and E.T.L. data sent on request.



GARDEN CITY PLATING & MFG. CO.
1760 N. Ashland Ave. · Chicago 22, Ill.

(Continued from page 26A)

tem, only 31 with the Calvert center-row system, and only 26 with the A.L.P.A. center-row system. True, this was not the fault of the station since the program had not been established early enough to permit the completion of the center-row systems until late in the season. But this does not alter the fact that such a large predominance of the slope-line system in the testing gave the test pilots much greater experience with that system and even with objective results no fair conclusions could be drawn. Much less can we place reliance on the subjective results obtained, since most persons, especially when their lives are at stake, tend to prefer the guidance with which they are most familiar.

Unfortunately no completely objective results, that is, results entirely free from opinions, were ever obtained at Arcata notwithstanding three years of effort to develop a reliable technique. Semi-objective results were available for 1948, but are not available for 1949, because the station was discontinued before the staff could complete the analysis.

The results of the comparison of slope-line and center-row systems at the L.A.E.S. may be summed up in the statement that there were no conclusive objective results, but the opinions of the L.A.E.S. test pilots, who had had some ten times as much experience with the slope-line as with the Calvert and 1949 A.L.P.A. systems combined, were somewhat in favor of the slope-line system with transverse bars. Had the station been allowed to concentrate on these three systems for another year it is likely that the relative merits of these systems would have been established.

On page 357, in the paragraph headed "*Slope-Line—Transverse Bars*" and in the legend under Figure 2, and again on page 358, the phrase "Garbell System" or "(Garbell) System" appears in such a way as to imply that Dr. Garbell invented an approach-light system. The slope-line system to which these references apply was conceived through the collaboration of A. J. Sweet, a man of outstanding originality, and H. J. C. Pearson, who has an excellent knowledge of the requirements of approach-light systems. The system was developed by these men, and after Mr. Sweet's death, by Mr. Pearson, with the assistance of others. The addition of transverse bars to this system was freely discussed by members of the Airport Lighting Evaluation Panel after Mr. Calvert of the Royal Aircraft Establishment had released several studies indicating the importance of such bars. At one of these discussions, at which Dr. Garbell was present, it was proposed that the transverse bars might be so designed as to give distance guidance as well as roll guidance. After an intermission, Dr. Garbell returned to the panel with a drawing showing the arrangement of bars included in Figure 2.

In attempting to clarify the status of the Pearson-Sweet slope-line approach-light system and Dr. Garbell's relation to it, I do not desire to overlook his contributions to the methods of evaluation used at the L.A.E.S. or the fact that the pilots considered the transverse bars an improvement in the slope-line system.
—F. C. Breckenridge, *National Bureau of Standards, Washington, D. C., Associated with the Airport Lighting Evaluation Panel throughout its existence as Technical Advisor or Chairman.*

ABOUT PEOPLE

The Austin Company has appointed **A. D. Engle** as assistant vice-president for research. Mr. Engle will be responsible for special engineering research work and some foreign assignments and will make his headquarters at the company's general offices in Cleveland.

Edgar C. Dehne has been elected assistant treasurer and assistant secretary of the Westinghouse Electric Corp., Pittsburgh. Formerly eastern district treasury manager, Mr. Dehne will be located in Pittsburgh. He succeeds **Edward George, Jr.**, who is retiring after 45 years of service with Westinghouse.

The Board of Directors of Sylvania Electric Products Inc., has elected **Barton K. Wickstrum** to the post of Vice President and Director of Sales. Mr. Wickstrum, who has been General Sales Manager of the Lighting Division, succeeds **Robert H. Bishop** who has resigned.

Nicholas E. Golovin has been appointed Assistant Director for Administration of the National Bureau of Standards. Mr. Golovin will be concerned with the planning and administrative management functions necessary for adequate support of the technical programs of the bureau.

Announcement has been made of the appointment of **Dr. Edward U. Condon** as director of research and development of Corning Glass Works. This was coincident with the acceptance by President Truman of Dr. Condon's resignation as Director of the National Bureau of Standards.

L. C. Kent, "dean" of the General Electric Lighting Institute, at Nela Park, Cleveland, retired September 1 after 38 years of continuous service with that company, 28 of which he directed the Institute's activities.

Rollo Gillespie Williams, formerly president of Color Lighting Corporation, which has been purchased by Duro-Test Corporation, North Bergen, N. J., has joined Duro-Test as General Sales Manager. Color Lighting will be operated as a wholly owned subsidiary, which will be headed by **James L. Cox.**

Zack G. Taylor, assistant manager of lamp manufacturing for General Electric Co., Nela Park, Cleveland, has retired under the provisions of the pension program after 39 years of service with the company.

Dr. Richard Feinberg, Dean of the College of Optometry, Pacific University, and Chairman of the Educational Committee of the Oregon Section, I.E.S., has resigned to accept the deanship of the Northern Illinois College of Optometry.

Duro-Test Corporation has created a new subsidiary, Duro-Test of California, to take over the company's activities on the West Coast. **William F. Bayne** will head the new company. Until new offices are completed, Mr. Bayne will make his headquarters at 420 Market Street, San Francisco.

Appointment of the Gerde-Pearson Sales Co., Minneapolis as sales representative for Northern Light Co., Milwaukee, has been announced. **Russ Gerde** and **Merrill Pearson** comprise this new sales team.

Cecil L. Cannon, formerly manager of lighting sales for Graybar Electric Co. in Atlanta, has joined **Oren M. Ruff** to form the firm of Ruff and Cannon. They are located at 152 Nassau Street in Atlanta and represent Day-Brite Lighting, Inc. in Georgia, Alabama and eastern Tennessee.

BOOKS AND PAMPHLETS

PC Daylighting Nomograph, 12-page photo-offset bulletin published by Pittsburgh Corning Corporation, Pittsburgh, Pennsylvania, February 1951.

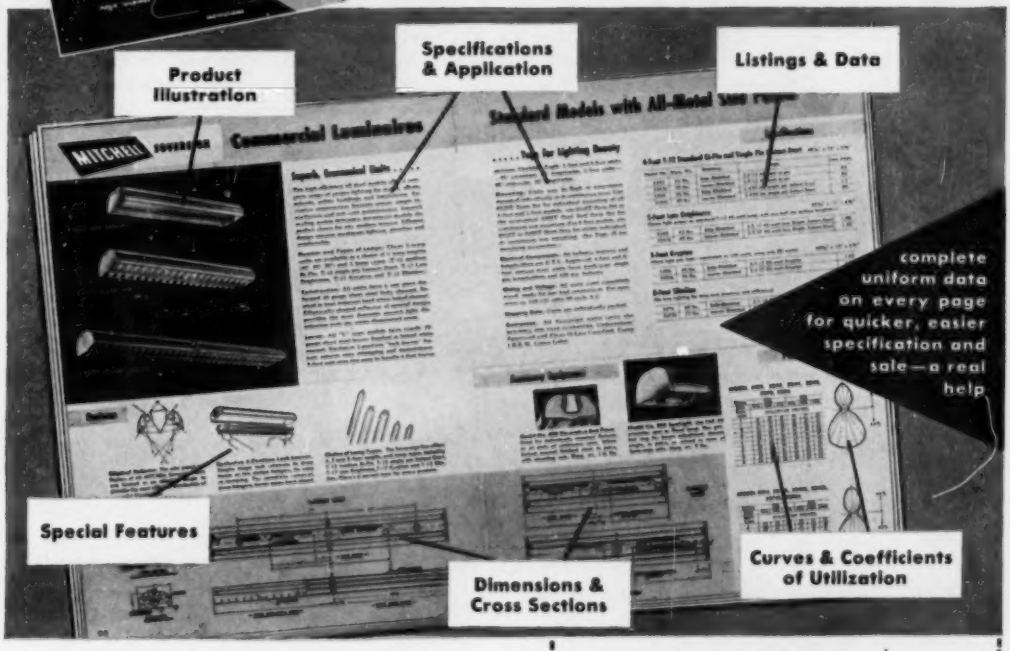
The nomograph relates exterior illumination on the fenestration and a "performance factor" for each fenestration area at various points within the room to desk level illumination in foot-candles. Other charts include data for determining exterior illuminations on the fenestration for various times of day and year from sky or sun and sky, and performance factors for several types of fenestration (glass block

(Continued on page 38A)

MITCHELL gives you 2 complete easy-to-use catalogs for quick, proper specification covering every lighting need

1 "DYNALITE" LIGHTING FOR INDUSTRY

2 COMMERCIAL FLUORESCENT LIGHTING


Product Illustration
Specifications & Application
Listings & Data
Special Features
Dimensions & Cross Sections
Curves & Coefficients of Utilization
complete uniform data on every page for quicker, easier specification and sale—a real help

For fast, simple specification of preferred quality lighting, use the new *complete* MITCHELL Catalogs. Here are full details on 74 superb Commercial Luminaires and 82 *Dynalite* Job-Rated Industrial units, presented in clear, quick-reference form. Select instantly the *exact* units you need to fill the bill for every lighting requirement. Rely on MITCHELL for the finest lighting equipment at sensible prices. Send for these new catalogs *now*.

MITCHELL MANUFACTURING COMPANY
2525 N. CLYBOURN AVE., CHICAGO 14, ILLINOIS
In Canada: Mitchell Mfg. Co., Ltd., 11-25 Davies Ave., Toronto

send for both

MITCHELL MANUFACTURING COMPANY
2525 N. Clybourn Avenue, Chicago 14, Illinois

Please send me a copy of

- ☐ Mitchell Commercial Lighting Catalog
- ☐ Mitchell "Dynalite" Industrial Lighting Catalog

*Name*_____

*Firm*_____

*Address*_____

*City*_____ *Zone*____ *State*_____

for PUSH CONTACT FLUORESCENT LAMPHOLDERS

THE ANSWER IS BRYANT

FEATURES

1. Spring-actuated plungers eliminate the hazard of falling lamps and assure good electrical contact with lamp pins.
2. Beryllium copper contacts for permanent, uniform spring pressure.
3. Discs of molded bakelite for long life.
4. Starter sockets and lampholders are in one unit to simplify installation.
5. Pin finders make relamping quick and easy.
6. Embossed arrows indicate lamps controlled by the starters.
7. Sturdy steel housings in white enameled finish.

No. 4393—Two lamp, 3½ inch lamp centers. 660 Watts, 600 Volts.

FOR USE WITH STANDARD BI-PIN LAMPS.

No. 4395—Two lamp, 5 inch lamp centers. 660 Watts, 600 Volts.

No. 4396—Three lamp, 2½ inch lamp centers. 660 Watts, 600 Volts.

For use with standard bi-pin lamps, single starter. Companion device No. 4397 (not shown) for two starters.

No. 4361—Two lamp, 5 inch lamp centers. 660 Watts, 250 Volts.

For two single pin slimline lamps, primarily T-12 (1½ inch)—but may be used with other slimline lamps. Companion device No. 4362 (not shown) 660 Watts 1000 Volts, has ribbed design on plungers as guide for lamp pin insertion. Both devices equipped with 12 inch leads.

BRYANT
SUPERIOR WIRING DEVICES

Listed As Standard By Underwriters' Laboratories, Inc.

THE BRYANT ELECTRIC COMPANY

Bridgeport 2, Connecticut

CHICAGO • LOS ANGELES

OFFICERS I. E. S. and COUNCIL 1951-1952

S. G. Hibben
President

E. M. Strong
Vice-President

A. H. Manwaring
Vice-President

Clarence C. Keller
General Secretary

R. F. Hartenstein
Treasurer

Walter Sturrock
Past President

C. H. Goddard
Past President

G. W. Beals
Director

R. L. Biesele
Director

L. A. Hobbs
Director

D. M. Jones
Director

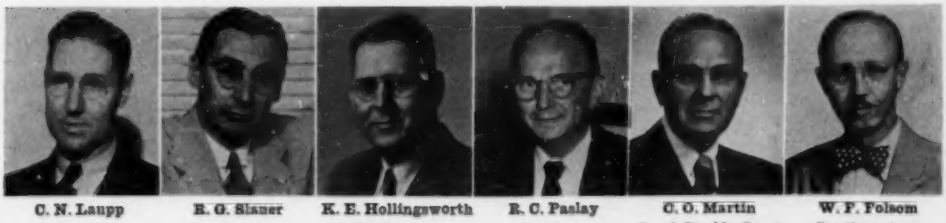
Roy A. Palmer
Director

J. S. Schuchert
Director

F. P. Labey
Canadian
Regional V-P

P. H. Hildebrand
East Central
Regional V-P

F. C. Winkler
Great Lakes
Regional V-P



C. N. Laupp
Midwestern
Regional V-P

R. G. Slaner
Northeastern
Regional V-P

K. E. Hollingsworth
Pacific Northwest
Regional V-P

R. C. Paslay
Southern
Regional V-P

C. O. Martin
South Pacific Coast
Regional V-P

W. F. Folsom
Southwestern
Regional V-P

I. E. S. Section and Chapter Chairmen For Year 1951-1952

Listing of Section and Chapter officers begins on page 35A.

Photograph of J. C. Silva, Chairman of the Mexico Chapter was not available in time for publication.

G. M. Baker
Alamo Chapter

J. M. Asher
Baltimore Chapter

H. J. Ashbee
British Columbia Section

R. P. Teele
Capital Section

N. E. Tindal
Carolinas Chapter

C. L. Cottrell
Central New York Chapter

R. R. Lusk
Chicago Section

R. N. Green
Cleveland Section

C. W. McCormick
Connecticut Section

E. E. Schwalm
Cornhusker Chapter

Frank E. Heins
Eastern Pa. Chapter

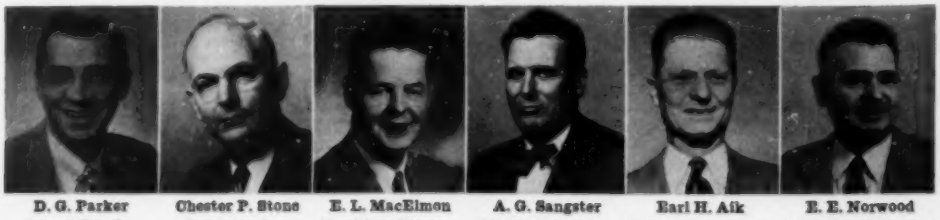
G. D. Leach, Jr.
Florida Chapter

T. Taylor Peake
Georgia Section

C. C. MacGregor
Hamilton, Ontario Chapter

F. I. Feagans
Heart of America Section

M. S. Gilbert
Indiana Chapter



D. G. Parker
Inland Empire Chapter

Chester P. Stone
Iowa Section

E. L. MacElmon
Maritime Chapter

A. G. Sangster
Michigan Section

Earl H. Aik
Milwaukee Section

E. E. Norwood
Mississippi Chapter

E. E. Morris
Montreal Section

Clark Baker, Jr.
Mother Lode Chapter

F. J. Vorlander
New England Section

R. C. Paslay
New Orleans Section

E. H. Salter
New York Section

S. M. Blacksmith
Northern California Section

M. H. Bigelow
Northwestern Ohio Chapter

G. H. Selter
Ohio Valley Section

E. R. Fletcher
Oregon Section

J. H. Rylance
Ottawa Chapter

P. B. Thorne
Philadelphia Section

N. C. Warner
Pittsburgh Section

F. C. Scharr
Puget Sound Section

Romeo Martineau
Quebec Chapter

H. G. Locke
Rochester Chapter

G. B. Buck, II
Rocky Mountain Section

G. S. Trotter
San Jacinto Section

N. H. Bollinger
Southeast Florida Chapter

S. H. Simonsen
Southern California Section

J. T. Meletio
Southwestern Section

J. J. Rhoades
St. Louis Section

S. B. LeCornu
Tennessee Valley Chapter

J. A. I. Kidd
Toronto Section

L. J. Riegert
Twin City Section

Wayne L. Shaw
Utah Chapter

J. W. McKinley
Western Michigan Chapter

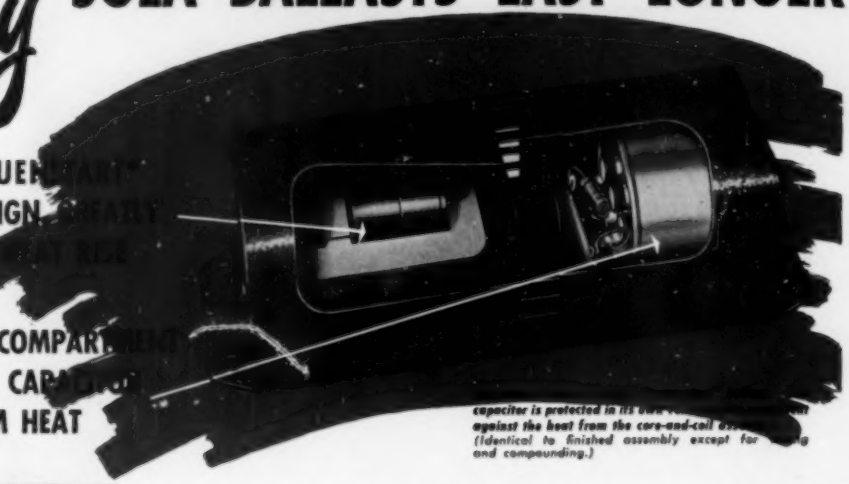
Neal Jacobus
Western New York Section

T. W. Birt
Winnipeg Chapter

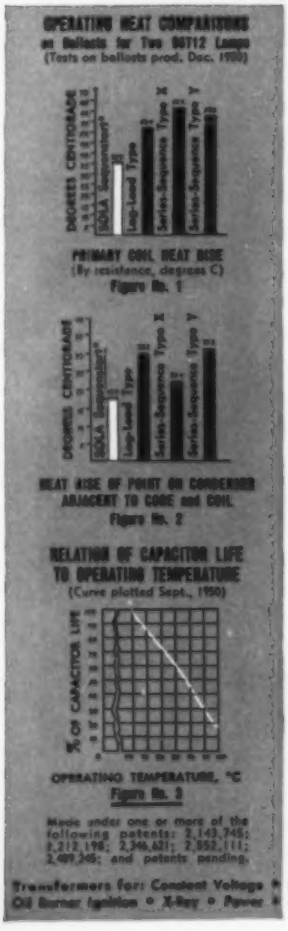
Why SOLA BALLASTS LAST LONGER

SOLA SEQUENSTART CIRCUIT DESIGN REDUCES HEAT RISE

VENTILATED COMPARTMENT PROTECTS CAPACITOR FROM HEAT



capacitor is protected in its ventilated compartment against the heat from the core-and-coil assembly. (Identical to finished assembly except for wiring and compounding.)


OPERATING HEAT COMPARISONS
on Ballasts for Two 96T12 Lamps
(Tests on ballasts prod. Dec. 1950)
DEGREES CENTIGRADE
SOLA Sequenstart*
Lag-Lead Type
Series-Sequence Type
Series-Sequence Type
PRIMARY COIL HEAT RISE
(By resistance, degrees C)
Figure No. 1
DEGREES CENTIGRADE
SOLA Sequenstart*
Lag-Lead Type
Series-Sequence Type
Series-Sequence Type
HEAT RISE OF POINT ON CONDENSER ADJACENT TO CORE and COIL
Figure No. 2
RELATION OF CAPACITOR LIFE TO OPERATING TEMPERATURE
(Curve plotted Sept., 1950)
% OF CAPACITOR LIFE
OPERATING TEMPERATURE, °C
Figure No. 3
Made under one or more of the following patents: 2,143,745; 2,212,198; 2,346,621; 2,552,111; 2,409,345; and patents pending.

Cool operation is vital to long ballast life. Excessive heat deteriorates impregnating varnish, enamel wire insulation, compound, and other ballast material. Most important, however, excessive heat invariably causes premature capacitor failure.

42.5%-32.2% COOLER CORE and COIL OPERATION

Primary coil temperature rise on SOLA Sequenstart* Ballasts is 42.5% - 32.2% lower, as illustrated by Figure 1. The patented SOLA Sequenstart* circuit greatly reduces the quantity of metal required, minimizing copper and iron losses. This reduces the high heat rise inherent in other designs and, consequently, lowers the high ambient temperature which surrounds ordinary ballasts.

VENTILATED CAPACITOR 13.2°C.-4.4°C. COOLER

Capacitor life is inversely proportional to operating temperatures (see Figure No. 3) . . . ballast life depends on capacitor life. SOLA design and manufacture minimizes capacitor failure in three ways:

- *Finest capacitors manufactured are inspected against rigid standards . . . 100% inspection after a baking cycle.*
- *The significantly lower heat rise of SOLA Sequenstart* Ballasts reduces radiated and conducted heat to the capacitor.*
- *The exclusive ventilated capacitor compartment isolates the capacitor from coil heat by two walls and a buffer of air. The insulating properties of the patented compartment are readily apparent from Figure No. 2. The lower capacitor temperature of the SOLA Ballast can result in as much as 35% longer capacitor life (see Figure No. 3).*

The important property of longer ballast life is but one of many advantages you'll receive when you specify and install SOLA Sequenstart* Ballasts.

New technical information about SOLA Ballasts is in preparation. If you are not on our mailing list, write to us. Ask for future releases on SOLA Fluorescent Ballasts.

SOLA Sequenstart® **BALLASTS**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs • Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC CO., 4633 W. 16th Street, Chicago 50, Illinois

National and Local Officers

Officers and Council 1951-1952

President—S. G. HIBBEN, Westinghouse Electric Corp., Bloomfield, N. J.

Vice-President — E. M. STRONG, Cornell University, Franklin Hall, Ithaca, N. Y.

Vice-President—A. H. MANWARING, Philadelphia Electrical & Mfg. Co., 1228 N. 31st St., Philadelphia 21, Pa.

Past-President—WALTER STURROCK, General Electric Co., Nela Park, Cleveland 12, Ohio

Past-President—C. H. GODDARD, Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

General Secretary—C. C. KELLER, Holophane Co., Inc., 342 Madison Ave., New York 17, N. Y.

Treasurer — R. F. HARTENSTEIN, Ohio Edison Co., Akron 8, Ohio

Directors

G. W. BEALS, The Miller Co., Meriden, Conn.

R. L. BIESELE, JR., 6514 Bandera, Dallas 5, Texas

L. A. HOBBS, Smoot-Holman Co., P. O. Box 398, Inglewood, Calif.

DUNCAN M. JONES, Curtis Lighting Co. of Canada, Ltd., 19 Ballantyne Ave., N., Montreal, Que., Can.

ROY A. PALMER, Duke Power Co., Power Building, Charlotte 1, N. C.

J. S. SCHUCHERT, Duquesne Light Co., 435 Sixth Ave., Pittsburgh 19, Pa.

Regional Vice-Presidents

Canadian Region—F. P. LABEY, Northern Electric Co., Ltd., 1620 Notre Dame St. W., Montreal, Que., Can.

East Central Region — PAUL H. HILDEBRAND, Pennsylvania Power & Light Co., 9th & Hamilton Sts., Allentown, Pa.

Great Lakes Region — F. C. WINKLER, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland 1, Ohio

Midwestern Region—CHARLES N. LAUPP, Wisconsin Electric Power Co., 231 W. Michigan St., Milwaukee 1, Wisc.

Northeastern Region—R. G. SLAUER, Sylvania Electric Products Inc., 60 Boston St., Salem, Mass.

Pacific Northwest Region—K. E. HOLLINGSWORTH, Puget Sound Power & Light Co., 5562 Stuart Bldg., Seattle 1, Wash.

South Pacific Coast Region—C. O. MARTIN, Benjamin Electric Mfg. Co., 829 Folsom St., San Francisco 7, Calif.

Southern Region — R. CECIL PASLAY, Louisiana Power & Light Co., 142 Delaronde St., New Orleans 14, La.

Southwestern Region — W. E. FOLSOM, Dallas Power & Light Co., Dallas 1, Texas

Section and Chapter Officers 1951-1952

Alamo Chapter—Southwestern Region

Chairman—GERALD M. BAKER, Route 2, Box 163-A, San Antonio 1, Texas

Secretary—C. E. SMITH, Square D Co., Travis Bldg., San Antonio 5, Texas

Baltimore Chapter—East Central Region

Chairman—J. M. ASHER, 2 Murdock Rd., Baltimore 12, Md.

Secretary—EDMUND S. BARRINGTON, 118 E. 24th St., Baltimore 18, Md.

British Columbia Section—Pacific Northwest Region

Chairman—H. J. ASHBEE, Amalgamated Electric Corp. Ltd., Granville Island, Vancouver, B. C., Can.

Secretary—R. W. RACINE, British Columbia Electric Co. Ltd., 570 Dunsmuir St., Vancouver, B. C., Can.

Capital Section—East Central Region

Chairman—R. P. TEELE, National Bureau of Standards, Connecticut Ave. & Van Ness St., N.W., Washington, D. C.

Secretary—CLAUDE R. ENGLE, JR., General Engineering Associates, 1928 Eye St., N.W., Washington, D. C.

Carolinas Chapter—Southern Region

Chairman—NORMAN E. TINDAL, 121 E. 3rd St., Charlotte, N. C.

Secretary — GEO. E. WILKINSON, Mill-Power Supply Co., 300 W. First St., Charlotte 1, N. C.

Central New York Chapter—Great Lakes Region

Chairman—CASPER L. COTTRELL, Cornell University, Franklin Hall, Ithaca, N.Y.

Secretary — JOSEPH H. GLAVY, General Electric Co., 113 S. Salina St., Syracuse 2, N. Y.

Chicago Section—Midwestern Region

Chairman—R. R. LUSK, Commonwealth Edison Co., 72 W. Adams St., Chicago 90, Ill.

Secretary — J. R. CHAMBERS, Benjamin Electric Mfg. Co., Des Plaines, Ill.

Cleveland Section—Great Lakes Region

Chairman — R. N. GREEN, The Wagner Green Co., 1935 Euclid Ave., Cleveland 15, Ohio

Secretary — W. S. KOLB, Westinghouse Electric Co., 1216 W. 58th St., Cleveland 1, Ohio

Connecticut Section—Northeastern Region

Chairman — CHARLES W. MCCORMICK, The Connecticut Light & Power Co., 250 Freight St., Waterbury, Conn.

Secretary — EDWARD R. COLE, Hartford Electric Light Co., 266 Pearl St., Hartford 3, Conn.

Cornhusker Chapter—Midwestern Region

Chairman—E. E. SCHWALM, Omaha Public Power District, Omaha, Nebr.

Secretary — R. W. GIBB, Omaha Public Power District, Omaha, Nebr.

Eastern Pennsylvania Chapter—East Central Region

Chairman—FRANK E. HEINS, 320 Sunset Rd., West Reading, Pa.

Secretary — MILES KEIFFER, Electrical Engineering & Construction Co., Manheim, Pa.

Florida Chapter—Southern Region

Chairman — G. D. LEACH, JR., Tampa Electric Co., P. O. Box 111, Tampa 1, Fla.

Secretary—ALLEN J. KEESLER, 4327 9th Ave. No., St. Petersburg, Fla.

Georgia Section—Southern Region

Chairman — T. TAYLOR PEAKE, Georgia Power Co., P. O. Box 1719, Atlanta, Ga.

Secretary — ROBERT J. KUZELL, Bob Kuzell & Co., 639 Whitehall St. S. W., Atlanta, Ga.

Hamilton Ontario Chapter—Canadian Region

Chairman—C. C. MACGREGOR, Campbell Electric Ltd., 131 Clarence St., Brantford, Ont., Can.

Secretary—B. FIELD, Wood, Alexander & James, Ltd., King William St., Hamilton, Ont., Can.

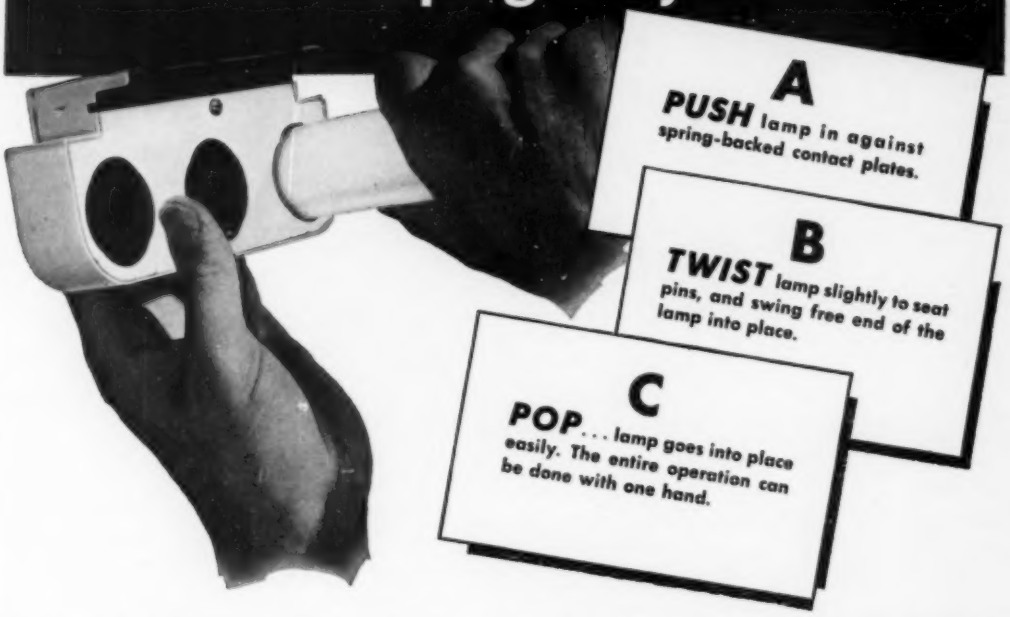
Heart of America Section—Midwestern Region

Chairman—FRANK I. FEAGANS, Kansas City Power & Light Co., P. O. Box 679, Kansas City, Mo.

Secretary—J. GORDON MCDONALD, Graybar Electric Co. Inc., 1644 Baltimore, Kansas City, Mo.

(*Continued on page* 37A)

Make Re-lamping easy as A B C


A
PUSH lamp in against spring-backed contact plates.
B
TWIST lamp slightly to seat pins, and swing free end of the lamp into place.
C
POP... lamp goes into place easily. The entire operation can be done with one hand.

Here's the really fast and easy way to re-lamp fluorescent fixtures with one hand. General Electric Turret* lampholders make maintenance as easy as A B C—let maintenance men take out old lamps and install new ones in a matter of seconds.

G-E Turret lampholders reduce the hazard of falling lamps. The simple locking action of the Turrets holds lamps in place without springs or clips.

G-E Turrets are just as easy to install as they are to maintain because the lampholder and starter sockets are housed as one unit in tough sheet steel.

They can be mounted conveniently on any flat surface—and are suitable for back-to-back mounting in continuous lighting installations.

And, for time-saving wiring, G-E Turrets feature straight-line guide holes. Simply insert stripped, tinned leads, and clamp in place with terminal screws. That's all.

For simplicity of installation and maintenance, insist on G-E Turret lampholders. Call the Accessory Equipment specialist at your local G-E office for details. Or, write Section Q70-1087, Construction Materials Division, General Electric Company, Bridgeport 2, Conn.

Watch Dog* Starters eliminate annoying flicker caused by failing lamps. Look for the red reset button.

Standard Starters. Glow-switch Type (voltage actuated) and Thermal Type (current actuated) cover the full range of fluorescent lamp requirements.

Standard lampholders and combination lampholders and starter sockets constitute a full line for most types of fluorescent fixtures.

Special lampholders including butt-on and waterproof types are all part of the G-E line.

*Registered Trade Mark of General Electric Company

You can put your confidence in—

GENERAL ELECTRIC

(Continued from page 35A)

Indiana Chapter—Midwestern Region

Chairman—MARCUS S. GILBERT, C.A.A. Experimental Station, P. O. Box 5767, Indianapolis 3, Ind.

Secretary—RANDALL L. BURLESON, Universal Electric Co., P. O. Box 72, Muncie, Ind.

Inland Empire Chapter—Pacific Northwest Region

Chairman — D. G. PARKER, Columbia Electric & Mfg. Co., Box 2180, Spokane 5, Wash.

Secretary—GEORGE I. MORRISON, Washington Water Power Co., P. O. Box 1445, Spokane 6, Wash.

Iowa Section—Midwestern Region

Chairman — CHESTER P. STONE, Blackhawk Electric Co., 623 Lafayette St., Waterloo, Iowa

Secretary—H. P. WILSON, Electrical Institute of the Tri-Cities, 1300 47th St., Des Moines, Iowa

Maritime Chapter—Canadian Region

Chairman—E. L. MACELMON, Board of School Trustees, 1 Hazen Ave., St. John, N. B., Can.

Secretary — C. T. ROBERTS, Northern Electric Co. Ltd., 10 Germain, St. John, N. B., Can.

Michigan Section—Great Lakes Region

Chairman—ALFRED C. SANGSTER, Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

Secretary — JOHN E. DAWSON, 12698 Greenlawn Ave., Detroit 5, Mich.

Milwaukee Section—Midwestern Region

Chairman — EARL H. AIK, Day-Brite Lighting Inc., 5816 W. Washington Blvd., Milwaukee 8, Wisc.

Secretary—BENJAMIN F. AVERY, General Electric Co., 161 W. Wisconsin Ave., Milwaukee, Wisc.

Mississippi Chapter—Southern Region

Chairman — E. E. NORWOOD, 1607 W. Capitol St., Jackson, Miss.

Secretary — LEIGH WATKINS, III, 1738 Linden Place, Jackson, Miss.

Montreal Section—Canadian Region

Chairman—EDWIN E. MORRIS, Electrolier Mfg. Co. Ltd., 5849 Boyer St., Montreal, Que., Can.

Secretary—R. H. SMITH, Northern Electric Co. Ltd., 1600 Notre Dame St. W., Montreal, Que., Can.

Mother Lode Chapter—South Pacific Coast Region

Chairman—CLARK BAKER, JR., 1337 Teneight Way, Sacramento 14, Calif.

Secretary—REX MOORE, JR., 1517 19th St., Sacramento 14, Calif.

New England Section—Northeastern Region

Chairman—F. J. VORLANDER, JR., Champion Lamp Works, 600 Broad St., Lynn, Mass.

Secretary—W. E. SCHWANHAUSSER, JR., General Electric Co., 920 Western Ave., Lynn 3, Mass.

New Orleans Section—Southern Region

Chairman — R. C. PASLAY, Louisiana Power & Light Co., 142 Delaronde St., New Orleans 14, La.

Secretary—HARRY T. BAILEY, JR., Louisiana Power & Light Co., 711 Second St., New Orleans, La.

New York Section—Northeastern Region

Chairman — E. H. SALTER, Electrical Testing Laboratories Inc., 2 East End Ave., New York, N. Y.

Secretary — MARSHALL N. WATERMAN, Westinghouse Electric Corp., Bloomfield, N. J.

Northern California Section—South Pacific Coast Region

Chairman — STANTON M. BLACKSMITH, Pacific Gas & Electric Co., 1625 Clay St., Oakland, Calif.

Secretary—BETH MCCRONE, Chas A. Von Bergen, 251 Kearney St., San Francisco., Calif.

Northwestern Ohio Chapter—Great Lakes Region

Chairman—M. H. BIGELOW, Libby-Owens-Ford Glass Co., 2112 Sylvan Ave., Toledo 6, Ohio

Secretary — ROSE M. COAKLEY, Toledo Edison Co., Edison Bldg., Toledo 4, Ohio

Ohio Valley Section—Great Lakes Region

Chairman—G. H. SEITER, American Gas & Electric Co., 4th & Main Sts., Cincinnati, Ohio

Secretary — EDWARD J. MCGINNIS, Cincinnati Electrical Association, 1106 Union Trust Bldg., Cincinnati 2, Ohio

Oregon Section—Pacific Northwest Region

Chairman — ELLSWORTH R. FLETCHER, Portland General Electric Co., 908 Electric Bldg., Portland 5, Oregon

Secretary—FRANK M. REIS, Pacific Power & Light Co., 920 S. W. Sixth St., Portland, Oregon

Ottawa Chapter—Canadian Region

Chairman—JAMES H. RYLANCE, 133 Russell Rd., Overbrook (Ottawa), Ont., Can.

Secretary — JOHN P. WILSON, Canada Electric Co., 90 Sherbourne St., Toronto, Ont., Can.

Philadelphia Section—East Central Region

Chairman—P. B. THORNE, General Electric Co., 1405 Locust St., Philadelphia 2, Pa.

Secretary — R. M. HOOT, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia 5, Pa.

Pittsburgh Section—East Central Region

Chairman — NELSON C. WARNER, Westinghouse Electric Corp., 306 4th Ave., Pittsburgh 30, Pa.

Secretary—JOHN B. RHEA, West Penn Power Co., 14 Wood St., Pittsburgh 30, Pa.

Puget Sound Section—Pacific Northwest Region

Chairman — FREEMAN C. SCHAER, 441 Dexter Horton Bldg., Seattle 4, Wash.

Secretary — G. D. KING, Puget Sound Power & Light Co., 101 Electric Bldg., Seattle, Wash.

Quebec Chapter—Canadian Region

Chairman — ROMEO MARTINEAU, La Cie Martineau Electrique Limitee, 24 Rue du Roi, Quebec, Que., Can.

Secretary—OSCAR DORVAL, 48 Mountain Hill, Quebec, Que., Can.

Rochester Chapter—Great Lakes Region

Chairman—H. G. LOCKE, 140 Irvington Rd., Rochester 7, N. Y.

Secretary—D. H .VINCENT, General Electric Co., 89 East Ave., Rochester 4, N. Y.

Rocky Mountain Section—Southwestern Region

Chairman—G. B. BUCK, II, General Electric Co., 1863 Wazee St., Denver 2, Colo.

Secretary — ARTHUR F. WEERS, Weers Electrical Planning Service, 1150 Jackson St., Denver 6, Colo.

St. Louis Section—Midwestern Region

Chairman — JOHN J. RHOADES, General Electric Supply Corp., 2653 Locust St., St. Louis 3, Mo.

Secretary — LELAND M. WALLACE, JR., Westinghouse Electric Corp., 411 No. 7th St., St. Louis 1, Mo.

San Jacinto Section—Southwestern Region

Chairman—GEORGE S. TROTTER, General Electric Co., 1811 National Standard Bldg., Houston 2, Texas

Secretary—E. C. OBER, Marlin Associates, 3420 McKinney, Houston 3, Texas

Southeast Florida Chapter—Southern Region

Chairman — N. H. BOLLINGER, Florida Power & Light Co., 25 S. E. Second Ave., Miami 32, Fla.

Secretary—H. M. BOSE, 1003 Chamber of Commerce Bldg., Miami 32, Fla.

Southern California Section—South Pacific Coast Region

Chairman—S. H. SIMONSEN, Ruby Lighting Corporation, 1212 So. Olive Street, Los Angeles, Calif.

Secretary—W. L. FRIEND, Sylvania Electric Products Inc., 2936 E. 46th St., Los Angeles, Calif.

Southwestern Section—Southwestern Region

Chairman—JAMES T. MELETIO, Meletio Electrical Supply Co., 315 So. Preston St., Dallas 1, Texas

(Continued on page 38A)

(Continued from page 37A)

Secretary—W. T. KIMERY, Dallas Power & Light Co., 1506 Commerce St., Dallas, Texas

Tennessee Valley Chapter—Southern Region

Chairman—SAMUEL B. LECORNU, Nashville Electric Service Co., 605 Church St., Nashville 3, Tenn.

Secretary—WALTER E. NASH, Westinghouse Electric Corp., P. O. Box 315, Nashville, Tenn.

Toronto Section—Canadian Region

Chairman—J. A. I. KIDD, Canadian General Electric Co. Ltd., 212 King St. W., Toronto, Ont., Can.

Secretary—D. J. MCKENZIE, Toronto Hydro Electric System, 14 Carlton St., Toronto, Ont., Can.

Twin City Section—Midwestern Region

Chairman—L. J. RIEGERT, Branham, Mareck & Duepner Inc., Box 27, St. Louis Park Station, Minneapolis 16, Minn.

Secretary—DONALD P. GREEN, Larson & McLaren, 1901 Foshay Tower, Minneapolis 2, Minn.

Utah Chapter—South Pacific Coast Region

Chairman—WAYNE L. SHAW, 5553 Holladay Blvd., Salt Lake City 7, Utah

Secretary—CLARK B. NEWELL, 1018 Lake St., Salt Lake City 4, Utah.

Western Michigan Chapter—Great Lakes Region

Chairman—J. W. MCKINLEY, 620 Rosewood Ave., Grand Rapids 6, Mich.

Secretary—J. A. DEWINTER, J & G Daverman Co., 924 Grandville Ave. S. W., Grand Rapids 9, Mich.

Western New York Section—Great Lakes Region

Chairman—NEAL JACOBUS, Sylvania Electric Products Inc., 407 Jackson Bldg., Buffalo 2, N. Y.

Secretary—GEORGE REINAGEL, Reinagel Lighting Co., 493 Franklin St., Buffalo 2, N. Y.

Winnipeg Chapter—Canadian Region

Chairman—T. W. BRIT, Winnipeg Electric Co., Electric Railway Chambers, Winnipeg, Man., Can.

Secretary—L. W. MACKENZIE, 36 Glen Ave., St. Vital, Man., Can.

Books and Pamphlets

(Continued from page 28A)

panels and clerestories, and shaded vision strips). Instructions are given for correcting the contribution from each fenestration area for area and azimuth so that the components can be added arithmetically. Limiting conditions include latitudes in U. S. and Canada, I.E.S. recommended room reflectances, room length, not less than ¾ width, height not less than ¼ width, and fenestration area not less than ⅛ floor area. Solutions to four sample problems conclude the publication.

Sun Angle Calculator and 31-page instruction booklet, available from Libbey-Owens-Ford Glass Company, Toledo 3, Ohio, 1951; price $9.50.

This device enables the architect or engineer to determine directly the sun's profile angle, azimuth, angle of incidence and altitude, obviating long calculations involving spherical trigonometry.

The calculator comprises an index map of the United States (to enable one to determine the latitude of the location to be studied), sun charts for each 4 degrees of latitude from 25 to 52 degrees north (with lines indicating the sun's path on the earth's surface as seen from that latitude for any time of day and year), a transparent overlay to be used with all charts (pivoted in the center so it can be rotated, and containing an indication of the location of the window or wall being considered and curves representing profile angles and angles of incidence), and a wedge-shaped cursor which pivots about the center on top of the overlay (with which one reads the altitude and bearing of the sun).

The instruction booklet explains how to use the calculator, two sample problems solved step-by-step, graphic methods for determining dimensions and location of sun control devices, principles of the solar house as related to the Sun Angle Calculator and shading devices, estimating solar heat gained through glass, two large-size nomograms for determining incident energy from sky and from the sun, the relation between solar and standard time, and finally transmission and absorption data for radiant energy incident on glass windows.

Construction and Equipment of the Home by the American Public Health Association Committee on the Hygient of Housing, published 1951 by Public Administration Service, 1313 East 60th Street, Chicago; 77 8½ x 10½-inch pages, 9 illustrations, 12 tables; price $2.50.

This, the third and final volume of a series (Planning the Neighborhood, 1948, and Planning the Home for Occupancy, 1950), is a group of special problems treated by specialists: the structural framework of the dwelling, problems of heating and ventilation, provision of adequate illumination, control of noise, provisions for sanitation in the home, equipment essential for good housekeeping, safety in the home, and the development of legal and administrative standards for dwelling construction.

The 18-page lighting chapter, written by Dr. Donald Y. Solandt of the University of Toronto covers the physiology of vision, the lighting levels recommended by the I.E.S.-A.P.H.A. Joint Committee, daylighting (both skylight and sunlight, including recommended glass to floor area ratios and the British daylighting factors), and artificial illumination including color and brightness considerations, home lighting equipment for both general and supplementary illumination, and recommendations for electrical outlets (from Industry Committee on Interior Wiring) and luminaires for various specific locations in homes.

Eyes in Industry by D. A. Campbell, W. J. B. Riddell and A. S. MacNalty, published by Longmans, Green and Co., Inc., New York, 1951; 250 6½ x 9¾ inch pages, 64 illustrations; price $6.50.

This volume summarizes industrial ophthalmology in layman's language. It is divided into three parts: Eyesight and Work which deals with the structure, functioning and nutrition of the eye, training of adolescents with defective vision, visual requirements in industry, eye defects common to adults, illumination, and aids to vision; Visual Hazards in Industry and Their Prevention; and Special Aspects of Industrial Eye Injuries and the Psychology of Sight. Appendices include First Aid Treatment of Eye Injuries, British Recommended Values of Illumination (not up to U. S. industrial practice), Visual Standards in Industry and Certificate of Blindness (both according to British law).

Operation Distribution, a 12-page pocket-size booklet, just issued by the National Association of Electrical Distributors, sets forth the position and services of the electrical distributor in

a defense economy. Prepared by the Association's Public Relations Committee for Cooperation with the Department of Defense, the booklet outlines the electrical distributor's position in today's economy, his contribution as a prime or sub-contractor in production of defense equipment and the role he is prepared to play in civilian defense.

In addition the booklet cites figures as to the size and scope of the electrical distributing industry. A copy of the booklet may be secured by addressing a request to the National Association of Electrical Distributors, 290 Madison Ave., New York 17, N. Y.

Annual Report of the National Bureau of Standards for 1950, National Bureau of Standards Miscellaneous Publication 200, 113 pages, 28 halftone illustrations, 50 cents (order from Government Printing Office, Washington 25, D. C.).

Summarizing the scientific investigations conducted by the National Bureau of Standards during the fiscal year 1950, a 113-page illustrated booklet, just published by the NBS, contains accounts of current activities as well as more detailed descriptions of especially important scientific developments.

The scope of research and development at the NBS, both theoretical and practical, is indicated by the names of the 13 scientific and technical divisions: electronics, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, applied mathematics, mineral products, building technology, heat and power, electricity and optics, metrology, and radio propagation.

Among accomplishments during the year were the NBS Eastern Automatic Computer, SEAC, the fastest general-purpose, automatically sequenced electronic computer now in operation; the NBS Electronic Currency Counter, designed for the Treasury Department to count old paper money at an hourly rate of 30,000 bills; and the highly precise omegatron, which discriminates between atomic particles of different masses.

(Note: Foreign remittances must be in U. S. exchange and should include an additional one-third the publication price to cover mailing costs.)

A new 287-page **Catalogue and Directory of the Lighting and Lamp Industry** is now available at five dollars per copy from Krieger Publications, Inc., 114 East 32nd Street, New York 16, New York. This volume, an outgrowth of the much-used "Post War Planning Directory of Manufacturers" which appeared in the November 1944 issue of *Lighting and Lamps*, fills a previous gap in the lighting field. The first two hundred pages, which are devoted to manufacturers' reference data (catalogue Section), and the following Directory Section will probably prove invaluable to many people in the industry. The Directory Section contains nearly 30,000 product listings under more than 300 classifications, representing more than 1500 manufacturers; a directory of over 400 trade names used in the lighting industry; and finally the addresses of all companies mentioned in the book. The bulk of the entries are for luminaires and luminaire parts, although manufacturers of incandescent, fluorescent and insect repellant lamps; finishing materials; lighting glassware; plastics; and decorative lighting are also included.

(*Continued on page* 42A)

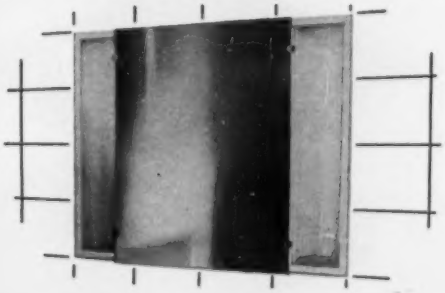
PERFORMANCE THAT ASSURES BETTER LIGHT

Acme Electric ballasts have been engineered to eliminate "strobe" effect, provide more lumen output, longer lamp life, quiet operation. Their better performance assure your customer's satisfaction.

ACME ELECTRIC CORPORATION
2910 WATER STREET CUBA, N. Y.

Acme Electric
TRANSFORMERS

MILWAUKEE FLUORESCENT BATHROOM CABINET



The only cabinet with *four* 20-watt lamps!

Now you can easily specify good lighting for the bathroom, too! The Milwaukee cabinet provides completely recessed lighting—for glareless, shadowless illumination. With *four* 20-watt fluorescent lamps, no other illumination is ordinarily needed in the bathroom. For all other facts on this most modern of bathroom cabinets, write for bulletin B-108. Or see your electrical wholesaler . . . today.

CHECK THESE SPECS: Uses four 20-watt lamps, shielded with Corning Alba-Lite translucent opal glass. Trigger-start G.E. ballasts. All-welded 20-gauge cold rolled steel. Mitered corners, filled and polished. Double-baked white lifetime enamel finish. Mirror of mirror-glazing quality polished plate glass. Polished edge glass shelves. U/L approved. Union made. G.E. electrical equipment. 110-120 volts, 60 cycle a-c. Individually packed. Requires a wall opening of 30⅝ x 24⅝ x 4 in.

NORTHERN LIGHT COMPANY MILWAUKEE

INDEX TO ADVERTISERS
October 1951

Acme Electric Corp.	39A
Art Metal Co.	20A
Bryant Electric Co.	30A
Champion Lamp Works	40A
Day-Brite Lighting Inc.	14A
Garden City Plating & Mfg. Co.	27A
General Electric Co., Const. Mat'ls.	36A
General Electric Co., Lamp	24A
Edwin F. Guth Co.	23A
Jefferson Electric Co.	12A-13A
Kopp Glass Inc.	19A
Leader Electric Co.	17A
Litecontrol Corp.	2A
Mitchell Manufacturing Co.	29A
Northern Light Co.	38A
R.L.M. Standards Institute	Inside Back Cover
Sola Electric Co.	34A
Sunbeam Lighting Co.	42A
Sylvania Electric Products Inc.	Back Cover
Unistrut Products Co.	41A
F. W. Wakefield Brass Co.	Inside Front Cover
Westinghouse Electric Corp., Lighting	1A

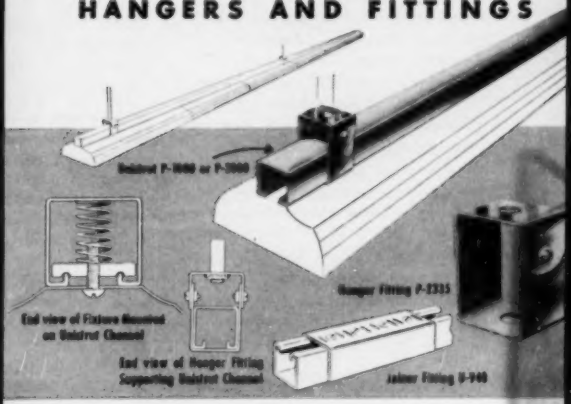
Another Fine Lighting Job

SUPPORTED BY

UNISTRUT®

HANGERS AND FITTINGS

BEFORE VIEW of study hall of Jackson High School, Jackson, Michigan. Approximately 49 ft. by 83 ft. with 20 ft. ceiling. Twenty-one 16-in. opal glassware chain suspension fixtures with 200 watt lamps. Fixtures suspended 10 ft. above floor. Average illumination was 5 to 8 foot candles.


End view of Fixture Mounted on Unistrut Channel
End view of Hanger Fitting Supporting Unistrut Channel
Hanger Fitting P-2335
Joiner Fitting P-940

AFTER VIEW of same study hall showing 4-lamp 40-watt fluorescent fixtures in continuous rows completely supported with Unistrut P-2000 Channel and suspended 13 ft. above floor with 3/4 in. conduit stems, canopies and Unistrut Hanger Fitting P-2335. Average maintained foot-candles is 35-40.

Lighting recommendations by and photographs courtesy of Consumers Power Company, Jackson, Michigan.

THE COMPLETELY MODERN METHOD of Hanging Fluorescent Fixtures gives you these Exclusive Advantages:

FEWER HANGER STEMS AND CANOPIES UNISTRUT'S great channel strength permits wider spacing of stems—up to 15 feet apart if desired—for better appearing installation and obvious savings.

PERFECT ALIGNMENT—UNISTRUT channel is rigid, strong and perfectly straight—gives you true alignment of fixtures. Cleaning, re-lamping, or other servicing cannot disturb this alignment.

COMPLETELY FLEXIBLE—Stems or rods can be installed at any point along UNISTRUT channel. Overcomes possible ceiling irregularities or obstructions. Ideal for continuous runs or intermittent spacing of fixtures.

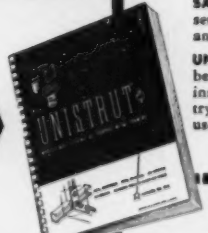
FASTER, EASIER INSTALLATION—UNISTRUT channel and fittings are attached to fixtures quickly and easily at normal working height or at suspension level. No drilling, no welding, 100% adjustable.

ADDED SAFETY—UNISTRUT assures the utmost safety of installation because an entire row of fixtures becomes a single integrated unit—added safety obtained by no other method.

SAVES TIME AND MONEY—Reduces number of canopy and stem sets used, lowers wiring and rewiring costs, eliminates drilling and welding costs, saves planning and installation time.

UNISTRUT APPROVED AS WIREWAY—UNISTRUT channel has been approved as a wireway by the department of electrical inspection in Chicago and 20 major cities throughout the country ... additional proof of the versatility and all around practical usefulness of UNISTRUT.

WRITE TODAY FOR YOUR FREE COPY OF NEW 78-PAGE CATALOG 700!



U. S. Patent Numbers
2327587 2329815 2360650
2363382 2380379 2405631
2541908 Other Patents Pending

UNISTRUT®
The World's Most Flexible All-Purpose Metal Framing

Representatives and Warehouse Stocks in Principal Cities
Consult Your Telephone Directories

UNISTRUT PRODUCTS CO.
1013 W. Washington Blvd. Chicago 7, Illinois

UNISTRUT PRODUCTS CO.
1013 W. Washington Blvd., Chicago 7, Ill., Dept. L-10.

Please send without obligation the items checked below:

☐ Catalog 700 ☐ Unistrut Sample

Name_____

Company_____

Address_____

City_____ Zone____ State_____

(Continued from page 39A)

Facts on Fluorescence, a four-page brochure assembled by the staff of the James A. Norris Company, 392 Bleecker Street, New York 14, N. Y., is an objective guide to answer many questions regarding the difference in each category of luminescence (fluorescent, black light, phosphorescence). This illustrated booklet is available at a cost of ten cents.

Standards of interchangeability for 30 different types and sizes of fluorescent lamps have been approved by the American Standards Association, 70 East 45th Street, New York 17, N. Y. and are available at 25 cents per copy.

The result of five years of study and investigation, the standards fully describe the lamp designation, dimensional characteristics, operating characteristics and starting requirements of each lamp. The lamp dimensions listed are those necessary for drawing plans for the manufacture of lamp holders, lighting fixtures and installations. Types included are preheat-start, instant-start single pin hot-cathode, bactericidal and cold-cathode electric discharge lamps.

Light for Plant Safety and Security, 24-page booklet, is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa. Stressing that protective lighting is good productive lighting, the booklet sets forth four principles. (1) discourage attempts at entry; (2) make detection certain if entry is attempted; (3) aid the guard and hinder the intruder; (4) provide complete reliability. Application suggestions and techniques are given, such as the lighting of isolated fence boundaries, building-face boundaries, water front boundaries and industrial thoroughfares. Various power distribution and control systems and mounting methods are provided.

Allotment Accounting for Consumers Under CMP, an 18-page booklet, has been issued by the Department of Commerce to help those companies which will operate under the Controlled Materials Plan in setting up the records they will have to maintain and in preparing the necessary forms. The booklet is available from the Office of Public Information, National Production Authority, Department of Commerce, Washington 25, D. C.

FIXTURE DESIGNER

Wanted to work on construction and design of fixtures and lighting systems in engineering department of New York fixture manufacturer of complete line of incandescent and fluorescent. Write giving experience. Address Box 147, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

ENGINEERING OPPORTUNITY

Large Northern Pacific Coast manufacturer has excellent opportunity for a mechanical engineer familiar with lighting fixtures. Write complete particulars to Box 144, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

REPRESENTATIVES WANTED

I.E.S. sustaining member, manufacturer of highest quality fluorescent and incandescent lighting equipment, with established national distribution and acceptance by leading architects and engineers, has available the following sales territories: Atlanta, Chicago, Cleveland, Florida, New Orleans, Northern New Jersey, Metropolitan New York, Pittsburgh. All inquiries will be held in strict confidence. Address Box 145, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

POSITION AVAILABLE

Product Design Engineer or Electrical Engineer with creative mind and a flair for designing and styling lighting fixtures is offered an unusual opportunity with a leading manufacturer of outdoor floodlighting and kindred fixtures. Located vicinity Metropolitan New York. Applications will be treated in strict confidence. Address Box 146, Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Every day marks another step forward in the science of lighting at Sunbeam. In contrast to the old days, the modern approach to luminaire designing is based on the concept of function. Backed by photometric research, Sunbeam visionaires* are designed to produce definite or specified illumination characteristics. On this premise, the style or appearance is also engineered. Because of this design program, you will find a fixture for every commercial purpose in the Sunbeam line. From showcase lighting to the most critical demands of industrial or commercial installations consult a Sunbeam engineer first.

The L1290 series; typical of Sunbeam's advanced concepts in lighting

This plastic, luminous-indirect type unit is designed specifically to achieve low contrasts between fixture and ceiling which means more visual comfort. Available in 2 or 4-lamp, 40W and all slimline lamp lengths. *®

Defense Production

makes more important than ever the Specification of Lighting Units that meet

RLM High Quality Standards

for Efficiency, Durability and Uniformity

Vital to defense and essential civilian production, are lighting units that *can be depended upon* to provide the right quantity and quality of light, economically, dependably and with a minimum of servicing need and maintenance cost.

Defense production demands lighting equipment with the ability to *sustain its rated light output* efficiency over hundreds of cleanings so that the proper high illumination levels may be maintained. It demands the *durability* found so essential to industrial lighting and the avoidance of production interruptions and inefficiency due to abnormal wear, distortion or breakdown. It demands fullest *protection from glare* through proper diffusion and shielding.

All of these, and many other conditions for proper lighting of defense plants can be met through the specification of RLM-Labeled Lighting Units. All units bearing the RLM Label are warranted by Electrical Testing Laboratories to conform to the minimum standards established by the RLM Standards Institute for efficiency, durability and uniform quality.

FREE RLM BOOKLETS containing complete specifications for all RLM-Certified Industrial Fluorescent and Incandescent Lighting Units and the names of all manufacturers of RLM-Labeled Units may be obtained by writing: RLM STANDARDS INSTITUTE INC., Suite 825, 326 West Madison Street, Chicago 6, Illinois.

Specification of RLM-Labeled Units Assures Conformance to ALL these Essentials of Defense Production Lighting

DIFFUSION WITH HIGH REFLECTION FACTOR
RLM Porcelain-Enameled Steel Reflectors must have a mean reflection factor of 82% . . . an assurance of more light for the money. Porcelain enamel reflecting surfaces *diffuse* light from the lamp and help provide proper *quality* of illumination.

TOP QUALITY PORCELAIN-ENAMELED REFLECTORS
RLM Reflectors are built of not less than .032" reflector steel covered with .025" fused on porcelain enamel that will not chip, corrode or deteriorate under industrial operating conditions.

APPROVED REFLECTOR DESIGN
Reflector design of RLM Units conforms to specifications embodying approved practices of illuminating engineering.

HIGH POWER FACTOR BALLASTS
RLM Standards specify the use of certified ballasts which last longer, because they are designed to prevent excessively high temperature operation.

UNIFORM QUALITY
RLM Standards insist on the maintenance of uniform quality as to materials and construction, thus assuring the buyer of uniform lighting performance from each unit installed.

RLM STANDARDS INSTITUTE
INCORPORATED

The Institute That Stands for Reflector and Lighting Equipment Standardization

GET THIS SENSATIONAL NEW BOOK ON...

COLOR and LIGHTING

A valuable, non-technical treatise prepared by Sylvania in conjunction with leading color analysts

Here is one of the most complete and fascinating books on color and lighting ever printed.

Written in layman's language it explains inter-relation of light and color. Enables you to predict how colors will appear under different light sources. Covers such subjects as Reflection and Absorption . . . Complementary colors . . . Color temperature . . . How we see color.

Shows actual color values best suited to each of Sylvania's 7 different white-tone fluorescent tubes.

It explains color fatigue, color systems, color harmony and much other information of importance to architects, lighting men, and interior decorators.

You'll agree this book is really an outstanding value. But, the supply is limited. Don't miss this offer! Mail the coupon and 50¢ for your copy NOW!

Reg. price $1.00

SPECIAL OFFER 50¢

Sylvania Electric Products Inc.
Dept. L-8110, 1740 Broadway
New York 19, N. Y.

Enclosed please find 50¢ for my copy of "Color is How You Light It."

Name_____

Street_____

City_____ Zone____ State_____

SYLVANIA

FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; PHOTOLAMPS; TELEVISION SETS

SYLVANIA ELECTRIC PRODUCTS INC. FIVE DECADES OF PROGRESS 50th ANNIVERSARY